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A Bibliography with Abstracts of US Army Engineer Waterways Experiment Station Publications Related to Vehicle Mobility

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PSTIAC REPORT NO. 3

A BIBLIOGRAPHY WITH ABSTRACTS OF U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION PUBLICATIONS RELATED TO VEHICLE MOBILITY

by

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August 1976

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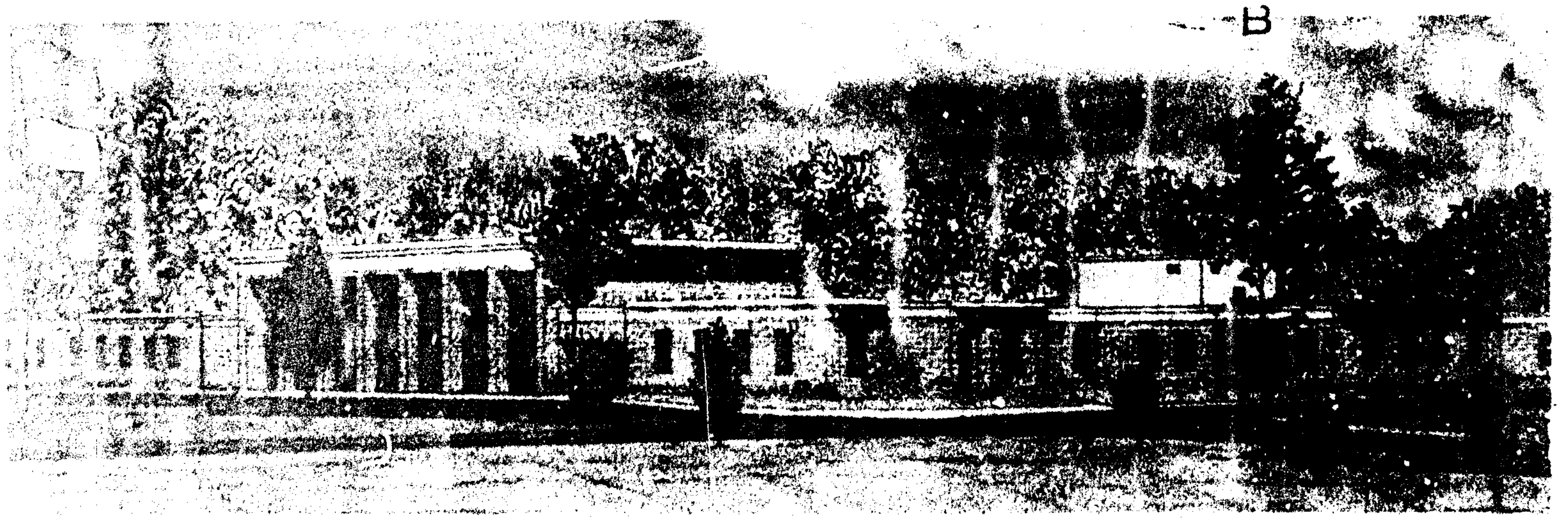

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The reports listed herein were published from 1945 through 1975 by personnel of or under contract to the Waterways Experiment Station. Indexes are included by subject, personal author, corporate author of contract reports, region, and military base. One part includes Document Control Data - R&D, or Report Documentation Page data that includes abstracts for each report.

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PREFACE

This publication is a bibliography with abstracts of unclassified reports on vehicle mobility published from 1945 through 1975 by the U. S. Army Engineer Waterways Experiment Station (WES). Most of the reports were prepared by personnel of or under contract to the Mobility and Environmental Systems Laboratory (MESL) of the WES; some of the reports were prepared by personnel of the Soils and Pavements Laboratory. Indexes are included by subject, personal author, corporate author of contract reports, region, and military base. One part contains Document Control Data - R&D or Report Documentation Page data (DD Form 1473) that include abstracts and other pertinent bibliographic information for each report.

The reports include research and development material on ground vehicle mobility and trafficability of terrain as related generally to military materiel and operations. The reports deal with vehicle characteristics, vehicle-driver interactions, vehicle-terrain interactions, characteristics of the terrain over which the vehicle moves, and characteristics of weather that influence terrain. The reports relate to vehicle and soil test equipment, tests of prototype vehicles in the field and their component parts in the laboratory, and tests of soil and snow properties pertinent to trafficability.

The reports have been distributed primarily to the sponsor and certain other agencies having an interest in the work reported. Most of the reports, particularly those published prior to 1970, are out of print. Available copies will be furnished without charge to Federal Government agencies on request until the supplies are exhausted. Reports with AD numbers can be obtained by Department of Defense agencies from the Defense Documentation Center; other agencies and individuals can obtain copies from the National Technical Information Service (see following paragraphs for additional information). Reports prefaced with the footnote "Statement B. See Preface" are limited in distribution or loan to U. S. Government agencies only unless permission for release can be obtained in special cases from the controlling office.

Library copies of the reports are available for loan from the WES Library Branch to Department of Defense agencies. The library loan privilege is e: ided to other Federal and state agencies, and except for those reports restricted as described above, to scientific and educational institutions and established engineering or industrial firms. In such cases the loan period is usually limited to 30 days. Private individuals not connected with the Department of Defense can usually arrange for library loan either through the main offices of their business concern or by having their local libraries arrange for interlibrary loan. Lending to persons outside the United States is not encouraged because of the extended time periods involved and risk of loss of publications in transit.

All matters concerning the distribution or loan of WES publications should be addressed to the Director, U. S. Army Engineer Waterways Experiment Station, ATTN: WESTV, Post Office Box 631, Vicksburg, Miss., 39180. Matters concerning the technical content of the reports should be addressed to the same address, ATTN: WESFV.

Except for a few reports, the WES no longer sells its publications. Reports listed in this volume having AD numbers can be purchased in microfiche or hard copy from the National Technical Information Service, U. S. Department of Commerce, 5285 Port Royal Road, Springfield, Va. 22161.

This bibliography was compiled by Mr. Marvin P. Meyer, Director, Pavements and Soil Trafficability Information Analysis Center, Stenographic assistance was provided by Mrs. Lottie Merritt, MESL. Miss Virginia Dale and Mrs. Rosemary Peck, Technical Information Center (TIC), assisted in organizing the Document Control and Report Document Page data. Mr. Woodland G. Shockley, Chief of the MESL, and Mr. A. A. Rula, Chief of the Mobility Systems Division, MESL, were responsible for overall supervision of the work. Mr. Alan G. Skelton, Chief of the TIC, supervised work conducted by TIC personnel. The U. S. Army Material Development and Readiness Command provided funds for the report.

COL G. H. Hilt, CE, was Director of the WES, and Mr. F. R. Brown was Technical Director during the report publication.

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ABBREVIATIONS

CR	Contract Report
IR	Instruction Report
M	Mobility and Environmental Systems Laboratory Report
MP	Miscellaneous Paper
NCG	Nuclear Cratering Group Report
PSTIAC	Pavements and Soil Trafficability Information Analysis Center Report
S	Soils and Pavements Laboratory Report
TM	Technical Memorandum
TR	Technical Report
U-7/70	Unnumbered Report - Month/Year of Publication
WES	Waterways Experiment Station

PART I

LIST OF REPORTS

Technical Memoranda

Number	Date	Title		AD Number
Unnumbered	Sep 1945	Trafficability of Soils		
3-240	Nov 1947	Trafficability of Soils, Pilot Tests, Self-Propelled Vehicles		AD 108 278
	Mar 1948	Supplement 1	Laboratory Tests to Determine Effects of Moisture Content and Density Variations	AD 108 279
	Aug 1948	Supplement 2	Trafficability Studies - Fort Churchill, Summer 1947	AD 108 280
	Oct 1948	Supplement 3	Development of Testing Instruments	AD 108 451
	Apr 1949	Supplement 4	Tests on Self-Propelled Vehicles, Yuma, Arizona, 1947	AD 108 452
	May 1949	Supplement 5	Analysis of Existing Data	AD 108 453
	Sep 1949	Supplement 6	Tests on Self-Propelled Vehicles, Vicksburg, Mississippi, 1947	AD 038 092
	Jun 1950	Supplement 7	Tests on Towed Vehicles, 1947-1948	AD 108 454
	May 1951	Supplement 8	Slope Studies	AD 108 455
	May 1951	Supplement 9	Vehicle Classification	
	Jan 1954	Supplement 10	Tests on Natural Soils with Self-Propelled Vehicles, 1949 and 1950	AD 034 076
	Aug 1954	Supplement 11	Superseded by Supplement 16	
	Nov 1954	Supplement 12	Tests on Natural Soils with Self-Propelled Vehicles, 1951-1953	AD 052 206
	Nov 1955	Supplement 13	Pilot Study, Tests on Coarse Grained Soils	AD 082 187
	Dec 1956	Supplement 14	A Summary of Trafficability Studies Through 1955	AD 121 975
	Jun 1959	Supplement 15	Tests on Coarse-Grained Soils with Self-Propelled and Towed Vehicles, 1956 and 1957	AD 218 089
	Aug 1961	Supplement 16	Soil Classification	AD 265 743
	May 1963	Supplement 17	Tests on Coarse-Grained Soils with Self-Propelled and Towed Vehicles, 1958-1961	AD 409 691
	Mar 1968	Supplement 18	Development of Revised Mobility Index Formula for Self-Propelled Wheeled Vehicles in Fine-Grained Soils, by J. G. Kennedy and E. S. Rush	AD 832 912
	Apr 1971	Supplement 19	Effects of Surface Conditions on Drawbar Pull of a Wheeled Vehicle, by E. S. Rush and J. H. Robinson	AD 723 406

Technical Memoranda

Number	Date	Title	AD Number
3-240 (Cont)	Apr 1974	Supplement 20 Development of Vehicle Performance Prediction Equations and Classification System for Coarse-Grained Soils, by J. G. Kennedy	AD 778 717
3-331		Forecasting Trafficability of Soils:	
	Oct 1951	Report 1 Meteorological and Soil Data, Vicksburg, Mississippi, 1948-1949	
	Jun 1952	Report 2 Meteorological and Soil Data, Vicksburg, Mississippi, 1949-1951	
	Oct 1954	Report 3 The Development of Methods for Predicting Soil Moisture Content:	
		Volume 1 Summary Report	AD 053 867
		Volume 2 Prediction Sites at Vicksburg, Miss.	AD 053 868
		Volume 3 Prediction Sites at Other Locations and Related Studies	AD 053 869
		Appendix Special Studies and Records of Soil Moisture and Weather	AD 053 870
	Feb 1957	Report 4 Information for Predicting Moisture in the Surface Foot of Various Soils	
	Jun 1959	Report 5 Development and Testing of Some Average Relations for Predicting Soil Moisture	AD 218 088
	Jun 1963	Report 6 Airphoto Approach:	
		Volume I	AD 409 916
		Volume II	AD 410 212
	Jun 1964	Report 7 A Pilot Study of Soils Subjected to Freezing and Thawing	AD 450 626
	Dec 1967	Report 8 Variability of Physical Properties of Loess Soils, Warren County, Mississippi, by C. A. Carlson and A. R. McDaniel	AD 824 443
	Jul 1968	Report 9 Water Table Study at Crossett, Arkansas, by J. R. Bassett and M. P. Meyer	AD 838 517
	Jul 1971	Report 10 Relations of Strength to Other Properties of Fine-Grained Soils and Sands with Fines, by J. C. Collins	AD 728 814
3-414		Trafficability of Snow:	
	Aug 1955	Report 1 Vehicles in Snow: A Critical Review of the State of the Art	
	Aug 1955	Report 2 Greenland Studies, 1954	AD 082 188
	May 1960	Report 3 Greenland Studies, 1955 and 1957	AD 239 552
	Dec 1960	Report 4 Tests on Subarctic Snow	AD 266 508

Technical Reports

Number	Date	Subject	AD Number
NCG 17	Jun 1969	Project TANK TRAP: A Field Evaluation of Nuclear Terrain Barriers	AD 693 817
3-462		Studies of Aerial Cone Penetrometer.	
	Jul 1957	Report 1 Laboratory Study of Mechanical Principles	AD 138 265
	Apr 1958	Report 2 Field Tests	AD 161 067
	Aug 1963	Report 3 Field Tests in Fine-Grained Soils, 1960	AD 450 613
	Jun 1970	Report 4 Impact Velocity-Impact Force Investigations, 1968, by J. G. Kennedy	AD 871 005
3-516		Deflection of Moving Tires	
	Jul 1959	Report 1 A Pilot Study on a 12x22.5 Tubeless Tire	AD 219 384
	Aug 1961	Report 2 Tests with a 12.00-22.5 Tubeless Tire on Asphaltic Concrete, Sand, and Silt, 1959-1960	AD 265 742
	May 1965	Report 3 Center-line Deflection Studies Through July 1963, by M. E. Smith and D. R. Freitag	AD 615 510
3-545		Stresses Under Moving Vehicles:	
		Report 1 in this series was published as Miscellaneous Paper No. 4-230	
	May 1960	Report 2 Wheeled Vehicles (M135), Lean and Fat Clay, 1957	AD 238 973
	Jul 1960	Report 3 Tracked Vehicles (M29C, D4, and D7) on Fat Clay, 1956	AD 241 537
	Jul 1964	Report 4 Distribution of Stresses on an Unyielding Surface Beneath Stationary and Towed Pneumatic Tires	AD 450 620
	Jul 1965	Report 5 Distribution of Stresses Beneath a Towed Pneumatic Tire in Air-Dry Sand, by A. J. Green and N. R. Murphy	AD 468 723
3-554	Jul 1960	Validation of Soil-Strength Criteria for Aircraft Operations on Unprepared Landing Strips	AD 241 546
3-565		Tests with Rigid Wheels	
	May 1961	Report 1 Tests in Fat Clay, 1958	AD 266 510
3-588		Project Otter (Overland Train Terrain Evaluation Research):	
	Dec 1961	Report 1 Pretest Report	AD 402 257
	Feb 1965	Report 2 Test Report, by J. H. Shamburger and L. M. Duke	AD 613 166
3-609	Aug 1962	Operation Swamp Fox I, Terrain and Soil Trafficability Observations	AD 290 529

Technical Reports

Number	Date	Title		AD Number
3-625	May 1963	Environmental Factors Affecting Ground Mobility in Thailand; Preliminary Survey		AD 411 528
		Appendix A	Results of Survey of Existing Data and Literature	AD 411 530
		Appendix B	Soil Classification	AD 411 533
		Appendix C	Soil Trafficability	AD 411 534
		Appendix D	Vegetation	AD 411 531
		Appendix E	Surface Geometry	AD 411 529
		Appendix F	Hydrologic Geometry	AD 413 984
		Appendix G	Weather and Climate	AD 411 532
		Appendix H	Evaluation of Road Observations	AD 411 535
3-639	Jan 1964	Strength-Moisture-Density Relations of Fine-Grained Soils in Vehicle Mobility Research		AD 450 623
3-641	Jan 1964	Trafficability Tests with the Marsh Screw Amphibian on Coarse-Grained and Fine-Grained Soils		AD 450 621
3-652		Measuring Soil Properties in Vehicle Mobility Research:		
	Aug 1964	Report 1	Strength-Density Relations of an Air-Dry Sand	AD 450 614
	Oct 1965	Report 2	An Evaluation of the Rectangular Hyperbola for Describing the Load-Deformation Response of Soils, by N. R. Murphy	AD 625 737
	Nov 1970	Report 3	Effects of Velocity, Size and Shape of Probes on Penetration Resistance of Fine-Grained Soils, by G. W. Turnage	AD 878 789
	Jul 1971	Report 4	Relative Density and Cone Penetration Resistance, by K.-J. Melzer	AD 729 367
	Jun 1973	Report 5	Resistance of Fine-Grained Soils to High-Speed Penetration, by G. W. Turnage	AD 763 184
	Jul 1974	Report 6	Measuring Soil Properties in Vehicle Mobility Research; Resistance of Coarse-Grained Soils to High-Speed Penetration, by G. W. Turnage	AD 781 991
	Jun 1975	Report 7	Measuring Soil Properties in Vehicle Mobility Research; Behavior of Fine-Grained Soils under High-Speed Tire Loads, by G. W. Turnage	AD A012 146
3-656		Trafficability Tests on Confined Organic Terrain (Muskeg)		
	Sep 1964	Report 1	Summer 1961 Tests, by N. W. Radforth and E. S. Rush	AD 450 618

Technical Reports

Number	Date	Title	AD Number
3-655 (Cont)	Dec 1965	Report 2 Summer 1962 Tests, by E. S. Rush, B. G. Schreiner, and N. W. Radforth	
		Volume I	AD 629 522
		Volume II	AD 735 773
3-665		Performance of Soils Under Tire Loads:	
	Jan 1965	Report 1 Test Facilities and Techniques, by J. L. McRae, C. J. Powell, and R. D. Wismer	AD 456 426
	Aug 1965	Report 2 Analysis of Tests in Yuma Sand Through August 1962, by C. J. Powell and A. J. Green	AD 621 045
	Feb 1966	Report 3 Tests in Clay Through November 1962, by R. D. Wismer	AD 631 020
	Feb 1966	Report 4 Analysis of Tests in Sand from September 1962 Through November 1963, by G. W. Turnage and A. J. Green	AD 632 245
	Jul 1967	Report 5 Development and Evaluation of Mobility Numbers for Coarse-Grained Soils, by A. J. Green	AD 817 122
	Oct 1967	Report 6 Effects of Test Techniques on Wheel Performance, by N. R. Murphy	AD 823 500
	Apr 1972	Report 7 Extension of Mobility Prediction Procedures to Rectangular-Cross Section Tires in Coarse-Grained Soil, by T. R. Patin	AD 741 770
	Sep 1972	Report 8 Application of Test Results to Tire Selection for Off-Road Vehicles, by G. W. Turnage	AD 751 750
3-670	Jan 1965	Wheels on Soft Soils; an Analysis of Existing Data, by D. R. Freitag	AD 457 8[illegible]
3-681		Mobility Environmental Research Study:	
	Jun 1965	Report 1 A Literature Survey of Environmental Factors in Thailand, by J. D. Broughton, J. H. Shamburger, and D. B. Del Mar	AD 620 030
3-688	Aug 1965	A Dimensional Analysis of the Performance of Pneumatic Tires on Soft Soils, by D. R. Freitag	AD 621 955
3-693		Terrain Analysis by Electromagnetic Means:	
	Oct 1965	Report 1 Laboratory Investigations in the 0.76- to 5.00-Micron Spectral, by B. R. Davis, E. B. Lipscomb, and S. J. Knight	AD 472 873
	Sep 1966	Report 2 Radar Responses to Laboratory Prepared Soil Samples, by J. R. Lundien	AD 802 104
	Nov 1967	Report 3 Laboratory Investigations in the 0- to 2.82-mev Gamma-Ray Spectral Region, by J. R. Lundien	AD 625 172

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Number	Date	Title	AD Number
3-693 (Cont)	May 1967	Report 4 Laboratory Investigations of the Infrared Emissivity of Soils Below a Wavelength of 7.7 Microns, by N. J. Lavecchia, A. N. Williamson, and H. J. Nikodem	AD 815 453
	Feb 1971	Report 5 Laboratory Measurement of Electromagnetic Propagation Constants in the 1.0- to 1.5-GHz Microwave Spectral Region, by J. R. Lundien	AD 881 799
3-702	Dec 1965	Characteristics of U. S. Rice Fields and Their Effects on Ground Mobility, by J. G. Kennedy and E. S. Rush	AD 628 734
3-703	Nov 1965	A Study of the Effects of Wet Surface Soil Conditions on the Performance of a Single Pneumatic-Tired Wheel, by J. L. Smith	AD 625 390
3-726		Mobility Environmental Research Study: A Quantitative Method for Describing Terrain for Ground Mobility:	
	May 1968	Volume I Summary, by J. H. Shamburger and W. E. Grabau	AD 835 392
	Jan 1968	Volume II Surface Composition, by R. C. Wright and J. R. Burns	AD 827 289
	Sep 1967	Volume III Surface Geometry, by W. K. Dornbusch	AD 820 788
	Mar 1968	Volume IV Vegetation, by J. D. Broughton and E. E. Addor	AD 830 184
	Nov 1967	Volume V Hydrologic Geometry, by E. E. Garrett and J. H. Shamburger	AD 827 290
	May 1966	Volume VI Selected Air-Photo Patterns of Terrain Features, by R. E. Frost, P. L. Johnson, R. D. Leighty, V. H. Anderson, A. O. Poulin and J. N. Rinker	AD 484 656
	Apr 1968	Volume VII Development of Factor-Complex Maps for Ground Mobility, by W. K. Dornbusch	AD 833 829
	June 1966	Volume VIII Terrain factor-Family Maps of Selected Areas	AD 487 500
3-727	Apr 1966	Feasibility Study of the Use of Radar to Detect Surface and Ground Water, by R. R. Davis, J. R. Lundien, and A. N. Williamson	AD 483 864
3-729	Jun 1966	Mechanics of Wheels on Soft Soils, A Method of Analyzing Test Results, by E. M. Leflaive	AD 485 854
	Nov 1967	Report 2 Effect of Width on Rigid Wheel Performance, by E. M. Leflaive	AD 824 232
3-732	Jun 1966	Comparison of Engineering Properties of Selected Temperate and Tropical Surface Soils, by M. F. Meyer	AD 486 478
3-744		Trafficability Tests on Unconfined Organic Terrain (Muskeg)	
	Nov 1966	Report 1 Summer 1963 Tests, by E. S. Rush and B. G. Schreiner	AD 805 328

Technical Reports

Number	Date	Title	AD Number
3-753	Jan 1967	Trafficability Classification of Thailand Soils, by M. P. Meyer	AD 808 540
3-783		An Analytical Model for Predicting Cross-Country Vehicle Performance:	
	Jul 1967	Appendix A Instrumentation of Test Vehicles, B. O. Benn and Malcolm Keown	AD 817 532
		Appendix B Vehicle Performance in Lateral and Longitudinal Obstacles (Vegetation)	
	Dec 1968	Volume I Lateral Obstacles, by C. A. Blackmon and J. K. Stoll	AD 846 257
	Jul 1968	Volume II Longitudinal Obstacles, by C. A. Blackmon and D. D. Randolph	AD 838 872
	Feb 1972	Appendix C Vehicle Performance in Vertical Obstacles (Surface Geometry), by C. A. Blackmon and N. R. Murphy	AD 737 687
	Feb 1970	Appendix D Performance of Amphibious Vehicles in the Water-Land Interface (Hydrologic Geometry), by C. A. Blackmon, B. G. Stinson, and J. K. Stoll	AD 866 165
	Apr 1971	Appendix E Quantification of the Screening Effects of Vegetation on Driver's Vision and Vehicle Speed, by B. G. Stinson	AD 724 070
	Aug 1970	Appendix F Soil-Vehicle Relations on Soft Clay Soils (Surface Composition), by C. A. Blackmon	AD 875 612
3-790	Jul 1967	Pilot Study of Response of CV-2 Aircraft to Irregular Terrain, by A. J. Green and E. S. Rush	AD 818 980
3-791		Moisture-Strength Characteristics of Selected Soils in Thailand:	
	Aug 1967	Volume I Analyses and Application of Data, by J. G. Kennedy, J. G. Collins, and M. H. Smith	AD 820 220
	Aug 1967	Volume II Basic Data, by J. G. Kennedy, J. G. Collins, and M. H. Smith	AD 820 221
*3-808	Jan 1968	Evaluation of the Performance of the XM759 Logistical Carrier, by B. G. Schreiner and A. A. Rula	AD 826 114L
M-68-1		Dynamics of Wheeled Vehicles:	
	May 1968	Report 1 A Mathematical Model for the Traversal of Rigid Obstacles by a Pneumatic Tire, by A. S. Lessem	AD 834 324
	Aug 1969	Appendix B Digital Implementation of Segmented Tire Model, by N. R. Murphy	AD 857 163

* Statement B. See Preface.

Technical Reports

Number	Date	Title	AD Number
M-68-1 (Cont)	Mar 1971	Report 2 Implementation of Wiener-Bose Theory and Application to Ride Dynamics, by A. S. Lessem	AD 723 403
	Apr 1971	Report 3 A Statistical Analysis of Terrain-Vehicle-Speed Systems, by N. R. Murphy	AD 723 405
	Mar 1972	Report 4 A Statistical Analysis of Obstacle-Vehicle-Speed Systems, by G. G. Switzer	AD 739 916
M-68-2	May 1968	Contribution to the Mechanics of Rigid Wheels on Sand, by K. W. Wiendieck	AD 833 871
M-69-2	May 1969	Improved Wheel Performance on Sand by Controlled Circumferential Rigidity, by K. W. Wiendieck	AD 688 876
M-70-1	Mar 1970	The Basic Sinkage Equations and Bearing Capacity Theories, by M. J. Hvorslev	AD 869 015
M-70-2	Mar 1970	Performance Evaluation of Wheels for Lunar Vehicles, by D. R. Freitag, A. J. Green, and K.-J. Melzer	AD 702 246
M-70-3	Mar 1970	Evaluation of WES Analytical Model in Selected Terrains (XM559E1 GOER Tests at Camp Gagetown, New Brunswick, Canada), by B. G. Stinson	
M-70-4	Mar 1970	Relative Off-Road Mobility Performance of Six Wheeled and Four Tracked Vehicles in Selected Terrain, by J. K. Stoll, D. D. Randolph, and A. A. Rula	
M-70-5	Apr 1970	Performance of Riverine Utility Craft (RUC) in Riverine Environments, by B. G. Schreiner, R. P. Smith, and C. E. Green	AD 869 011
M-70-6	Apr 1970	Quantitative Description of Selected West German Terrain for Ground Mobility, by H. K. Woods and J. H. Shamburger	
M-70-7		Evaluation of the Relative Off-Road Performance of 15 Vehicles in Synthalogous Theaters of Operation (STOP) Terrain Factor Complexes:	
	May 1970	Volume I Application of an Analytical Model for Predicting and Evaluating Vehicle Performance in STOP Terrain Factor Complexes; and Appendix A: Analytical Model for Predicting Cross-Country Vehicle Performance, by D. D. Randolph	
	May 1970	Volume II Appendix B: Vehicle Performance Predictions in Tropical Climate Theater; Appendix C: Vehicle Performance Predictions in Arid Climate Theater; Appendix D: Vehicle Performance Predictions in Temperate Climate Theater, by D. D. Randolph and R. H. Johnson	
M-70-8	Jun 1970	A Preliminary Study of Seafloor Trafficability and Its Prediction, by K. W. Wiendieck	AD 710 965
*M-70-10	Jul 1970	Relative Off-Road Mobility of MBT70 and M60A1E1 Tanks in Selected Terrains in West Germany, by A. A. Rula, C. A. Blackmon, B. G. Stinson, and J. K. Stoll	AD 511 150L

* Statement B. See Preface.

Technical Reports

Number	Date	Title	AD Number
M-70-11		Mobility Exercise A (MEXA) Field Tests Program:	
	Mar 1971	Report 2 Volume 1, Performance of MEXA and Three Military Vehicles in Soft Soil, by B. G. Schreiner	AD 883 199
	Jul 1970	Report 3 Performance of MEXA and Three Military Vehicles in Lateral Obstacles, by J. L. Decell	AD 875 940
	Jan 1974	Report 4 Performance of Selected MEXA and Military Vehicles in Vertical Obstacles, by N. R. Murphy, Jr., and A. A. Rula	
M-70-12	Jul 1970	European Waterways Study; a Procedure for Describing Tactical Gaps, by P. R. Friesz, A. P. Desmarais, K. S. Fife, W. G. Willis, and W. E. Grabau	
*		Volume I	AD 875 511L
*		Volume 2	AD 875 512L
*		Volume 3	AD 875 540L
M-70-14		Penetration Resistance of Soils:	
	Nov 1970	Report 1 Tests with Circular Footings in Air-Dry Sands, by A. J. Green	AD 715 979
	Nov 1970	Report 2 Gamma-Ray Techniques for Nondestructive Measurements of Soil Density and Density Profile, by A. N. Williamson	AD 715 980
	Jul 1971	Report 3 Tests with Circular Footings in Cohesive Soils, by A. J. Green	AD 726 368
M-70-15	Oct 1970	Performance of Boeing-GM Wheels in a Lunar Soil Simulant (Basalt), by A. J. Green and K.-J. Melzer (Superseded by M-71-10, Report 1)	
*M-71-1	May 1971	Performance Evaluation of a First-Generation Elastic Loop Mobility System, by K.-J. Melzer and A. J. Green	AD B007 715L
M-71-4	Jul 1971	An Analysis of Ground Mobility Models (ANAMOB), by A. A. Rula and C. J. Nuttall	AD 886 513
M-71-5		Performance of Soils Under Track Loads:	
	Jul 1971	Report 1 Model Track and Test Program, by G. W. Turnage	AD 728 496
	Nov 1971	Report 2 Prediction of Track Pull Performance in a Desert Sand, by G. W. Turnage	AD 733 926
M-71-6	Sep 1971	Prediction of the Slope-Climbing Capability of Elastic-Rim Wheels, by K. W. Wiendieck	AD 731 205
M-71-7	Oct 1971	Effect of Yaw Angle on Steering Forces for the Lunar Roving Vehicle Wheel, by A. J. Green	AD A006 518

* Statement B. See Preface.

Technical Reports

Number	Date	Title	AD Number
M-71-8	Nov 1971	Performance of Dual-Wheel Configurations in Coarse-Grained Soil, by K.-J. Melzer	AD 732 864
M-71-10		Performance of the Boeing LRV Wheels in a Lunar Soil Simulant:	
	Dec 1971	Report 1 Effects of Wheel Design and Soil, by A. J. Green and K.-J. Melzer	AD 756 213
	Dec 1971	Report 2 Effects of Speed, Wheel Load, and Soil, by K.-J. Melzer	AD A006 498
M-72-1	Jun 1972	Studies of the Dynamics of Tracked Vehicles, by A. S. Lessem and N. R. Murphy	AD 743 464
M-73-1	Sep 1972	Vehicle Mobility Assessment for Project Wheels Study Group (With Addenda), by A. A. Rula, C. J. Nuttall, Jr., and H. J. Dugoff	AD A008 286
*M-73-5	Aug 1973	A Numerical Model of the Ride Dynamics of a Vehicle Using a Segmented Tire Concept, by W. F. Ingram	AD 913 281L
S-73-13	Dec 1973	Vehicle/Road Compatibility Analysis and Modification Systems (VRCAMS), by V. C. Barber and N. R. Murphy	AD 772 962
M-74-1	Jan 1974	Helicopter Movement on Unimproved Terrain, by E. S. Rush and C. E. Green	AD 780 698
*M-74-3	Apr 1974	A Variable-Stress Vehicle Reliability Model, by A. S. Lessem	AD 919 333L
M-74-7	Jun 1974	Performance Evaluation of a Second-Generation Elastic Loop Mobility System, by K.-J. Melzer and G. D. Swanson	
S-74-7	Sep 1974	Stresses and Shearing Resistance in Soil Beneath a Rigid Wheel, by M. M. Al-Hussaini and P. A. Gilbert	AD A000 609
M-75-1	Jun 1975	Small-Scale Mobility Tests in Fine-Grained Layered Soils, by G. D. Swanson, and T. R. Patin	AD A013 491

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Miscellaneous Papers

Number	Date	Title	AD Number
4-19	Nov 1952	Report on Trafficability Conditions and Airfield Site Selection in an Area in Norfolk County, East Anglia England	
4-73	Sep 1954	A Study of Moisture-Content Determinations on Selected Soils	AD 041 085
4-101	Nov 1954	Trafficability Survey of Selected Areas, Camp Stewart Georgia	
4-117	Mar 1955	Field Tests of Nuclear Instruments for the Measurement of Soil Moisture and Density	AD 073 388
4-135	Jul 1955	The Development of Methods for Predicting Soil Moisture Content, Report on the Fairbanks, Alaska, Extension	AD 747 826
4-147	Jan 1956	Vehicle Mobility on Soft Soils	AD 841 344
4-230		Stresses Under Moving Vehicles:	
	Jul 1957	Report 1 A Pilot Study of WES Earth Pressure Cell Action in Comparatively Soft Soil (See TR 3-545 for subsequent reports in this series)	AD 841 345
4-238	Nov 1957	Statistical Occurrence of Soil Strength	
4-241	Oct 1957	Vehicle Mobility	AD 841 346
4-282	Aug 1958	Comparison of Performance Characteristics in Snow of the Polecat and Weasel	
4-284	Aug 1958	A Limited Study of Factors That Affect Soil Strength	
4-298	Jan 1959	Meteorological and Trafficability Data, U. S.-Canadian Arctic Weather Stations	AD 756 305
4-300	Jan 1959	Aerial Penetrometer Demonstration at Fort Rucker, Alabama	AD 625 601
4-322	Feb 1959	A Limited Study of Snap-Tracs	AD 756 291
4-327	Mar 1959	Effect of Mold Size and Other Factors on Laboratory Cone Index Measurements	AD 841 347
4-338	Apr 1959	Prediction of Soil Moisture from Soil and Weather Records	AD A006 496
4-350	Jul 1959	Pilot Study to Evaluate the Squeeze Test for Use in Vehicle-Mobility Research	AD 841 348
4-355		Trafficability Predictions in Tropical Soils:	
	Sep 1959	Report 1 Four Soils in the Panama Canal Zone	AD A006 520
	Feb 1960	Report 2 Puerto Rico Study	

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Number	Date	Title	AD Number
4-355 (Cont)	Aug 1966	Report 3 Panama Study No. 2 (October 1961-September 1963), by A. R. McDaniel	AD 801 321
*	Nov 1967	Report 4 Columbia Study (July 1962-July 1963), by A. R. McDaniel	AD 824 754L
*	Dec 1967	Report 5 Costa Rica Study No. 1 (January 1963-January 1965), by A. R. McDaniel	AD 824 882L
	Nov 1968	Report 6 Puerto Rico Study No. 2 (March 1962-November 1963), by J. G. Kennedy and T. E. Hicks	AD 845 616
	Nov 1970	Report 7 Hawaii Study, by C. A. Carlson, W. P. Bohnert, and M. P. Meyer	AD 877 577
*	Aug 1971	Report 8 Costa Rica Study No. 2 (January 1964-September 1965), by A. R. McDaniel and M. H. Smith	AD 888 001L
4-362	Oct 1959	Preliminary Study of Stresses Under Off-Road Vehicles	AD 841 349
4-365	Nov 1959	Traffic Evaluation Tests of Rogers Dry Lake, California	
4-371	Jan 1960	Laboratory Tests of Liquid Nitrogen Soil-Moisture Samplers	AD 756 311
4-394	May 1960	Strength Requirements in Unsurfaced Soils for Aircraft Operations	
4 404	Jul 1960	The Army Mobility Research Center Testing Facility	
4-412	Nov 1960	A Limited Study of the Performance of the 2-Ton Meili Flex-Trac	AD 756 321
3-428	Jan 1961	Physical Components of the Shear Strength of Saturated Clays	
4-438	Jul 1961	Trafficability Tests with Jumbo Truck on Organic and Coarse-Grained Mineral Soils	AD 756 331
4-439	Aug 1961	Trafficability Tests with the Airoll on Organic and Mineral Soils	AD A006 497
4-441	Aug 1961	Measurement and Estimation of the Trafficability of Fine-Grained Soils	
4-442	Aug 1961	Soil Trafficability Classification Scheme	
4-443	Aug 1961	The Behavior of Sand Under Pneumatic Tires	
4-444	Aug 1961	Classification of Terrain for Mobility Purposes	AD 666 222
4-446	Aug 1961	Comparison of Trafficability of Muskeg with Trafficability of Other Soft Soil Terrains	AD 754 332
4-447	Aug 1961	Properties of Surface Soils in the West Season	AD 754 335
4-457	Nov 1961	Some Factors Affecting Moisture Content-Density-Cone Index Relations	AD 753 641

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Number	Date	Title	AD Number
4-461	Dec 1961	A Technique for Mapping Trafficability	AD 754 334
4-462	Dec 1961	Measuring Soil Trafficability Characteristics	AD 754 333
4-463	Dec 1961	Stresses in Yielding Soils Under Moving Wheels and Tracks	
4-469	Feb 1962	Distribution of Stresses on an Unyielding Surface Beneath a Pneumatic Tire	
4-477	Apr 1962	Trafficability Tests with the 5-Ton GOER (XM520) on Fine- and Coarse-Grained Soils	AD 646 591
3-482	Apr 1962	Predicting Soil-Moisture Distribution in Areas of Seasonal Frost, Feasibility Study	AD 756 302
4-497	May 1962	Deflection of a Moving Tire on Firm to Soft Surfaces	
4-505	Aug 1962	Operation Wheeltrack, Camp A. P. Hill, Virginia, 25-30 April 1962	
4-513	Jul 1962	Airoll Performance in Snow	AD 744 463
Unnumbered	Aug 1962	Report of Mobility Consultants Conference, Waterways Experiment Station, Vicksburg, Mississippi, 13-15 June 1962	
4-528	Sep 1962	Documentation of Conditions Attendant to Army Tactical Mobility Requirements (Howze) Board Testing	AD 744 213
4-535	Oct 1962	A Technique for Estimating the Slope-Climbing Ability of Wheeled Vehicles in Sand	AD 744 214
4-547	Jan 1963	Identifying Soil Parameters with an Infrared Spectrophotometer	AD 744 220
4-556	Jan 1963	Visit to Swamp Fox II Operation	
3-592	Jul 1963	Terrain Evaluation for Mobility Purposes	AD 744 216
4-594	Aug 1963	Visit to University of Illinois to Discuss Tropical Soils Studies	AD 744 217
4-602	Oct 1963	Study of the Characteristics of Rice Fields in the United States	AD 744 215
4-621	Jul 1963	Speed Tests Conducted in Canada During Muskeg Trafficability Test Program, August 1962	AD 744 219
4-623	Feb 1964	Comments on Mobility Research	AD 744 221
4-626	Feb 1964 Revised Sep 1964	Theory for a Towed Wheel in Soil	AD 744 132
4-629	Feb 1964	Normal Stresses at the Tire-Soil Interface in Yielding Soils	AD 744 224
4-630	Feb 1964	Terrain Reconnaissance with Electromagnetic Sensors	
4-638	Apr 1964	The Terrain-Vehicle Programs of the U. S. Army Engineer Waterways Experiment Station	AD 744 218
4-647	Apr 1964	Variation in the Trafficability of Sands	

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Number	Date	Title	AD Number
4-651	May 1964	Tracks Versus Wheels in Soft Soil and Snow	AD 744 222
4-652	May 1964	A Comparison of Quantitative Versus Nonquantitative Terrain Descriptive Systems for Mobility Analysis	AD 745 148
4-670	Aug 1964	Report of Second Meeting of ARPA Advisory Committee on Mobility Environmental Research Study (24-26 February 1964, Vicksburg, Mississippi)	AD 478 994
4-687	Dec 1964	Retention of Detail in Map Generalization, by E. E. Addor and W. E. Grabau	AD 745 149
4-702	Feb 1965	Vicksburg Mobility Exercise A, Vehicle Analysis for Remote-Area Operation, by S. J. Knight	AD 613 366
4-713	Mar 1965	Trafficability of Snow in Arctic and Subarctic Regions, by B. G. Schreiner	AD 745 150
4-726		Mobility Environmental Research Study:	
	Jun 1965	Report 1 Selection and Description of Test Areas, U. S. Military Reservations, by H. K. Woods and J. H. Shamburger	AD 745 151
4-743	Oct 1965	Tests to Evaluate the Mobility of Jiger and Fisher Vehicles, by M. P. Meyer	AD 901 950
3-749	Nov 1965	Statistical Evaluation of Cone-Penetration-Test Data, by J. K. Poplin	AD 736 121
4-750	Nov 1965	Center-Line Deflection of Pneumatic Tires Moving in Dry Sand, by D. R. Freitag and M. E. Smith	AD 745 152
4-751	Nov 1965	Trafficability Tests with the Marsh Screw Amphibian, by S. J. Knight, E. S Rush, and B. G. Stinson	AD 745 153
4-757	Nov 1965	A Study of the Effects of Wet Surface Soil Conditions on the Performance of a Single Wheel, by J. L. Smith	AD 745 154
4-758	Dec 1965	Mechanics of Wheels on Soft Soils; A Method for Presenting Test Results, by E. M. Leflaive	AD 746 399
4-766	Jan 1966	Tests wth the CH-47A Chinook Helicopter in Soft Clay Soil, by E. S. Rush	AD 627 377
4-767	Jan 1966	Effects of Air Surcharge on the Bearing Capacity of Soft Cohesive Soils, by L. J. Lanz	AD 630 804
4-769	Dec 1965	Traffic Tests to Determine the Benefits of Vegetation in Increasing Traffic Coverages, by L. M. Womack	AD 745 622
4-791	Feb 1966	Report of Conference of the Board of Consultants on Remote Terrain Analysis by Electromagnetic Means; Waterways Experiment Station, 18-19 November 1965	AD 747 095
4-822	May 1966	Effects of Soil Layering on the Use of VHF Radio Waves for Remote Terrain Analysis, by H. J. Nikodem	AD 747 096

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Number	Date	Title	AD Number
4-823	May 1966	Laboratory Investigations of the Gamma-Ray Spectral Region for Remote Determination of Soil Trafficability Conditions, by A. N. Williamson	AD 747 097
4-828	Jul 1966	Development of a Formula for Towing Resistance for a Wheel in Soft Soil, by J. L. McRae	AD 746 400
4-829	Aug 1966	Comparison of Ground Mobility Characteristics of Land-Marine Interfaces in Florida and Thailand, by E. E. Garrett	AD 800 075
4-835	Aug 1966	A Dimensional Analysis of the Performance of Pneumatic Tires on Clay, by D. R. Freitag	
4-836	Aug 1966	A Dimensional Analysis of the Performance of Pneumatic Tires on Sand, by D. R. Freitag	AD 716 341
4-838	Aug 1966	Variation in Trafficability of Four Loess Soils, by J. R. Bassett, A. R. McDaniel, and S. J. Knight	AD 800 144
4-854	Nov 1966	Concepts for Vehicles for Off-Road Use in Remote Areas, by A. A. Rula, D. R. Freitag, and S. J. Knight	AD 746 401
3-861	Dec 1966	Terrain Evaluation of a Portion of the Fort Greely Automotive Test Course; Final Report, by J. H. Shamburger, C. R. Kolb, and H. K. Woods	AD 806 538
4-870	Feb 1967	Theory for Predicting Performance of a Wheel in Soft Soil, by J. L. McRae	
4-879	Mar 1967	Trafficability Tests in Fine-Grained Soils with Two Vehicles with 9- to 10-Ton Wheel Loads, by E. S. Rush	AD 811 217
unnumbered	Apr 1967	Report of Conference on Soil Trafficability Prediction, U. S. Army Engineer Waterways Experiment Station, 29-30 November 1966	AD A019 176
4-893	May 1967	Bumps and Grinds: Study in Body Motions, by W. G. Shockley	AD 747 098
4-899	May 1967	Aerial Cone Penetrometer for Measuring the Trafficability of Soils, by S. J. Knight	AD 746 402
4-917	Aug 1967	Trafficability Tests with a Two-Wheel-Drive Industrial Tractor, by E. S. Rush and B. G. Stinson	AD 819 857
4-921	Aug 1967	A Suggested Procedure for the Selection and Description of Reference Test Areas, by W. E. Grabau	AD 658 659
4-923	Aug 1967	Flotation Requirements for Aircraft, by R. G. Ahlvin and D. N. Brown	AD 739 551
*4-940	Oct 1967	Soil Buildup Between Wheels and Sponson of XM759 Logistical Carrier, by E. S. Rush	AD 902 843L
4-942	Oct 1967	Effects of Tread Pattern on the Surface Traction of Terra-Tires, by J. L. Smith	AD 747 099
4-944	Nov 1967	A Qualitative Approach to the Pneumatic Tire-Soft Soil System, by L. M. Kraft	AD 823 995

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Number	Date	Title	AD Number
*4-948	Sep 1967	Ground-Flotation Investigation of Model Wide Tire, by J. E. Watkins and W. J. Hill	AD 822 345L
4-949	Dec 1967	Expedient Surface-Soil Sampling, by S. J. Knight and C. A. Blackmon	AD 746 350
4-950	Dec 1967	A Limited Study of Effects of Soil Strength on Walking Speed, by E. S. Rush and A. A. Rula	AD 746 403
4-959	Jan 1968	Application of Trafficability Analysis to Forestry, by D. R. Freitag and B. Y. Richardson	AD 746 404
4-960	Jan 1968	Penetration Tests for Soil Measurements, by D. R. Freitag	
4-961	Jan 1968	Summary of Comparison of Engineering Properties of Selected Temperate and Tropical Surface Soils, by M. P. Meyer	AD 746 757
4-979	Mar 1968	Report of Second Meeting Vicksburg Mobility Exercise A, Design of Field Test Program (8-10 February 1967, Vicksburg, Mississippi)	
4-986	Apr 1968	Gamma-Ray Measurements to Evaluate Soil Properties, by A. N. Williamson	
M-68-1	Aug 1968	Effects of Test Techniques on Wheel Performance, by N. R. Murphy and A. J. Green	AD 746 758
M-68-2	Aug 1968	Description and Comparison of Tire Performance in Sand in Terms of Energy Parameters, by E. M. Leflaive	AD 746 759
M-68-4	Sep 1968	Trafficability Tests with Major/Minor Wheel Vehicle Equipped with 16x14.5-6 Tires, by J. H. Robinson and E. S. Rush	AD 841 855
M-68-5	Dec 1968	Simulating Dynamic Ride Characteristics of Pneumatic Tires, by A. S. Lessem	
M-68-6	Dec 1968	Stress-Displacement Relations and Terrain-Vehicle Mechanics: A Critical Discussion, by K. W. Wiendieck	
M-68-7	Dec 1968	A Mathematical Model for Traversal of Rigid Obstacles by a Pneumatic Tire, by A. S. Lessem and A. J. Green	
M-68-8	Dec 1968	A Theoretical Evaluation of the Shear-to-Normal Stress Ratio at the Soil-Wheel Interface, by K. W. Wiendieck	
M-69-1	Jan 1969	Trafficability Tests with a Rubber-Tired Log Skidder, by B. Y. Richardson, J. H. Robinson, and R. P. Smith	AD 848 416
M-69-2	Jun 1969	Vehicle Dynamics Research at Waterways Experiment Station, by A. J. Green and G. G. Switzer	AD 746 760

* Statement B. See Preface.

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Number	Date	Title	AD Number
M-69-4	Sep 1969	Limited Trafficability Tests with Major/Minor Wheel Vehicle Equipped with 20x14-10 Tires, by J. H. Robinson and R. P. Smith	AD 859 719
M-69-5		Utility Carrier Development Program:	
	Oct 1969	Report 1 Limited Study of Effects of Jungle Trail Characteristics on Performance of Selected Self-Propelled Vehicles, by E. S. Rush	AD 753 427
*	Oct 1969	Report 2 Limited Study of Effects of Vegetation Characteristics on Performance of Selected Self-Propelled Vehicles, by J. L. Decell, T. D. Hutto, and A. A. Rula	AD 902 842L
M-69-6	Dec 1969	The Role of Ground Crawling Vehicles in the Ocean, by K. W. Wiendieck and D. R. Freitag	
M-69-7	Dec 1969	Effects of Cone Velocity and Size on Soil Penetration Resistance, by G. W. Turnage and D. R. Freitag	
M-69-8	Dec 1969	A General Theory of Stresses and Displacements in Elastic and Viscoelastic Layered Systems, by Yu-Tang Chou	
S-69-15	Apr 1969	Evaluation of Nuclear Methods of Determining Surface In Situ Soil Water Content and Density, by T. B. Rosser and S. L. Webster	AD 688 079
*M-70-2	Apr 1970	Worldwide Strength Conditions of Surface Materials, by W. P. Bohnert and M. P. Meyer	AD 869 490L
M-70-4	May 1970	Performance Evaluation of Wheels for Lunar Vehicles (Summary Report), by D. R. Freitag, A. J. Green, and K.-J. Melzer	AD 705 570
M 70-6	May 1970	Effect of Pressure Distribution Under Pneumatic Tires on Stresses and Displacements in the Supporting Elastic Media, by Y. T. Chou	
M-70-7	Sep 1970	A Plan for Quantitative Evaluation of the Cross-Country Performance of Prototype Vehicles, by W. E. Grabau, J. K. Stoll, and B. G. Stinson	AD 877 016
M-70-8	Dec 1970	Tests with an Experimental Wheel on Clay, by K. W. Wiendieck	
*M-70-9	Dec 1970	Limited Performance Tests of the XM759, 1-1/2-ton Logistical Carrier, Amphibious, by B. G. Shreiner and E. S. Rush	AD 879 172L

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Number	Date	Title	AD number
M-70-10	Dec 1970	Effects of Soil Surface Conditions on Drawbar Pull of a Wheeled Vehicle, by E. S. Rush	
S-70-14	May 1970	Evaluation of Soil Strength of Unsurfaced Forward-Area Airfields by Use of Ground Vehicles, by G. M. Hammitt	AD 709 589
S-70-24	Sep 1970	Soil Strength Criteria for Operation of Fighter Aircraft On Unsurfaced Airfields; Bare Base Support; Project 3782-65, by D. M. Ladd	AD 756 158
S-70-25	Nov 1970	The Effects of Geological Features on Soil Strength, by E. L. Krinitzsky	AD 756 159
M-71-1	Feb 1971	Standard Penetration Test and Relative Density, by K.-J. Melzer	
M-71-2	Feb 1971	Evaluating Penetration Tests in Clay from Measured Soil Particle Movements, by Y. T. Chou	
M-71-3	Feb 1971	The Performance of Two Boeing-GM Wheels (GM VII and GM VIII) for the Manned Lunar Rover Vehicle, by A. J. Green and K.-J. Melzer	
M-71-4	Mar 1971	Event Dial Pack; Project LN309: Effectiveness of Craters as Barriers to Mobility, by C. A. Blackmon and A. A. Rula	AD 720 986
M-71-5	Jun 1971	Utilization of Synthetic Soils in Engineering Research, by A. J. Green	AD A006 519
M-71-7	Nov 1971	Automation of Cross-Country Locomotion Model, by J. A. Parks and J. K. Stoll	
M-72-2	Apr 1972	Effect of Design Changes on Vehicle Performance; A Limited Study of the M35A2 (Modified) and the M113A1	AD A017 725
M-72-3	Apr 1972	Operations and Maintenance Manual for a Scale-Model Lunar Roving Vehicle, by A. S. Lessem	AD 757 392
M-72-5	May 1972	Evaluation of Surface Shear Strength Measurements for Use in Laboratory Mobility Studies, by T. R. Patin	AD 743 167
S-72-9	Mar 1972	Notes on Proving Rings and Frames for Soil Testing Equipment, by M. J. Hvorslev	AD 756 199
*S-72-34	Nov 1972	Relative Surfacing Requirements for Container-Handling Vehicles, by D. N. Brown, A. A. Clark, R. J. Lacavich, and E. S. Rush	AD 905 195L
M-73-1	Jan 1973	Automation of a Model for Predicting Soil Moisture and Soil Strength (SMSP Model), by M. H. Smith and M. P. Meyer	AD 755 095
M-73-2	Apr 1973	Power Requirements for Wheels Operating in Fine-Grained Soils, by K.-J. Melzer	AD 759 501
M-73-4	May 1973	Suggested Method for Application of the WES VCI/RCI Criteria to Helicopters and Related Ground Support Equipment, by E. S. Rush	AD A017 731

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Number	Date	Title	AD Number
M-73-5	Jun 1973	Event Mixed Company III; Project LN305: Effectiveness of Craters as Barriers to Mobility, by C. E. Green	AD 910 627
M-73-6	May 1973	Project DIAMOND ORE; Phase IIA: Effectiveness of Craters as Barriers to Mobility, by C. A. Blackmon and C. E. Green	
M-73-7	May 1973	Analysis of the Ability of a Laser Profilometer System to Evaluate Unprepared Landing Sites, by L. E. Link, Jr.	AD 763 180
*M-73-14	Sep 1973	Vehicle Mobility Assessment of Munitions Transfer Truck on Selected Areal Terrains, by B. G. Shreiner and W. E. Willoughby	AD B007 716L
M-73-15	Dec 1973	The Effect of Military Transportation Activities on the Environment, by A. J. Green, D. D. Randolph, and A. A. Rula	
M-73-16	Dec 1973	Prediction of Aircraft Ground Performance by Evaluation of Ground Vehicle Rut Depths, by G. W. Turnage and D. N. Brown	AD 775 744
Unnum-bered	Mar 1974	Terrain Analysis for the Armored Reconnaissance Scout Vehicle Test Program, by D. D. Randolph and C. A. Blackmon	AD 776 387
M-74-1	Apr 1974	A Limited Study of the Performance of an Interim 3/4-Ton Wheel/Track Convertible Test Rig, Houghton, Michigan, and Vicksburg, Mississippi, by W. E. Willoughby	
M-74-3	May 1974	A Preliminary Study of Scale-Model Bulldozer Blades	
M-74-5	Aug 1974	Beach Trafficability Testing with Off-Road Materials Handling Equipment, Anzio Beach, Little Creek, Virginia, by E. S. Rush	AD A017 723
*M-74-6	Aug 1974	Mobility Validation Test Results for the Armored Reconnaissance Scout and Comparison Vehicles, by W. E. Willoughby and B. G. Schreiner	AD B003 764L
M-74-7	Sep 1974	Characterization of Selected Road Sections in Western United States, by A. A. Rula and J. H. Robinson	AD A018 289
M-74-8	Oct 1974	Mapping of Selected ARSV Test Courses at Fort Knox, Kentucky, and Comparison with Other Selected Terrains, by D. D. Randolph	AD A001 520
M-75-3	Apr 1975	Project ESSEX I, Phase 1, Mobility Experiments, by C. E. Green	AD A011 493
*M-75-4	May 1975	Terrain Description, Vehicle Mobility and Cover Concealment Characteristics for the Bushmaster Middle East and Europe Scenarios; A Qualitative Assessment, by H. W. West and B. G. Schreiner	AD B005 325L
M-75-5	Jun 1975	Comparison of the Ride Qualities of Standard M60A1 and Hybrid (Tube-Over-Bar) M60A1E3 Tanks, by N. R. Murphy Jr. and J. H. Robinson	AD A013 986

* Statement B. See Preface.

Miscellaneous Papers

Number	Date	Title	AD Number
M-75-7	Jun 1975	WES Papers Presented at Fifth International Conference, International Society for Terrain-Vehicle Systems, June 2-6 1975, Detroit-Houghton, Michigan	AD A012 653
M-75-8	Aug 1975	Estimating the Performance Capability of 50,000-lb Capacity Container Handler on Beach and Desert Sands, by E. S. Rush and G. N. Durham	AD A014 273

Instruction Reports

Number	Date	Title	AD Number
Unnumbered	Oct 1961	Tropical Soil Studies; Plan of Tests	
Unnumbered	Jan 1962	Tropical Soil Studies in Panama and Puerto Rico; Plan of Tests	
7	Oct 1965	Description and Application of Airfield Cone Penetrometer, by W. B. Fenwick	AD 800 746
S-70-1	Apr 1970	Rapid Assessment of Soil Strength at Aircraft Landing Sites, by G. M. Hammitt	AD 705 572
S-74-1	Apr 1974	Determination of In-Place Moisture and Density by Nuclear Methods, by S. L. Webster	AD 779 422
	Jun 1974	Errata Sheet No. 1	

Pavements and Soil Trafficability Information Analysis Center Reports

Number	Date	Title	AD Number
1	Apr 1975	Microthesaurus of Vehicle Mobility, Environment, and Pavement Terms	AD A011 269
2	Nov 1975	Bibliography of Papers Presented at Meetings or in Technical Journals on Studies of the Mobility and Environmental Systems Laboratory, by M. P. Meyer	AD A018 290

Contract Reports

Number	Date	Contractor and Title of Report	AD Number
		Purdue University, Engineering Experiment Station	
4-6		Application of Airphoto Pattern Analysis to Soil Trafficability Studies:	
	Jun 1951	Book One By O. W. Mintzer, E. J. Yoder, and J. R. Shepard	
	June 1951	Book Two Glacial Patterns	
		Book Three Alluvial Patterns	
	Dec 1952	Book Three (Second Edition) Water Deposited Materials	
	Jun 1951	Book Four Miscellaneous Patterns	
	Feb 1954	Book Five Wind Deposited Soils	
	Jun 1954	Book Six Residual Materials (in 2 parts)	
	Sep 1956	Supplement No. 1 Prepared by R. D. Miles and R. D. Leighty	
	Dec 1957	Supplement No. 2 Glacial Deposited Materials, prepared by R. D. Miles and D. G. Shurig	
		U. S. Forest Service	
4-8		The Development of Methods for Predicting Soil Moisture Content	
	Nov 1951	Progress Report I	
		Volume I, by E. J. Dortignac and H. W. Lull	
		Volume II, by E. J. Dortignac and H. W. Lull	
	Jul 1952	Progress Report II	
		Purdue University, Engineering Experiment Station	
4-12A	Oct 1954	Effect of Soil Moisture and Other Natural Variables on Aerial Photo Gray Tones	
		Cornell University	
3-15	May 1955	An Environmental Analysis of the Fort Churchill, Manitoba, Region, by T. A. Cheney and D. K. B. Beckel	
		Text I	
		Text II	
		Folio	
		Wilson, Nuttall, Raimond Engineers, Inc.	
4-16	Oct 1955	Vehicle Mobility Research: A Preliminary Review of Major Accomplishments and Current Activities in the Field, by C. J. Nuttall	
4-17	Mar 1956	Vehicle Mobility Research, 1956: A Review and a Suggested Program, by C. J. Nuttall	

Contract Reports

Number	Date	Contractor and Title of Report	AD Number
		Purdue University	
4-20	Sep 1956	Techniques for Predicting Soil Trafficability Information from Aerial Photographs, by R. D. Miles	
		U. S. Geological Survey, Military Geology Branch	
3-22	1957	Terrain Study of the Army Test Area, Fort Greely, Alaska	
		Volume 1 Text, by G. W. Holmes and W. S. Benninghoff	
		Volume 2 Maps	
		FMC Corporation, Ordnance Engineering Division	
3-33	Sep 1964	A Research Study Concerning the Application of a Fourier Series Description to Terrain Geometries Associated with Ground Mobility and Ride Dynamics Phase I: Terrain and Vehicle Models	
		University of Illinois	
3-38	Oct 1959	Report on Survey of Literature in Connection with the Dynamic Bearing Capacity of Soils, by Narbey Khachaturian	
		Texas Instruments Incorporated	
4-96		Phase I System Analysis for a Waterways Experiment Station Terrain Analysis Radar (Project WESTAR); Final Report	
	Jan 1963	Phase II System Implementation, Waterways Experiment Station Terrain Analysis Radar (Project WESTAR); Final Report and Engineering Handbook	AD 465 402
	Jan 1965	Phase III Analysis of Results, Waterways Experiment Station Terrain Analysis Radar (Project WESTAR); Final Report	AD 465 403
4-100	Mar 1964	Final Report Waterways Experiment Station Terrain Analysis Gamma (Project WESTAG)	
		Purdue University	
3-108	Nov 1953	Statistical Analyses of Trafficability Data, by Paul Irick	
		Wilson, Nuttall, Raimond Engineers, Inc.	
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		U. S. Army Engineer Ohio River Division Laboratories		
3-118	Aug 1965	Photoelastic Studies for Vehicle Mobility Research, by F. M. Hellinger, J. H. Hubbard, and R. L. Peters		AD 621 221
		Wilson, Nuttall, Raimond Engineers, Inc.		
3-119	Nov 1964-Jun 1965	Summary of Trafficability Tests Through 1963 (in 11 volumes)		
3-120	Mar 1965	An Exploratory Study of the Effects of Terrain Surface Obstacles on Vehicle Performance; Final Draft, by G. T. Cohron and R. A. Werner		
3-130	Dec 1965	A Dimensionless Consolidation of WES Data on the Performance of Sand Under Tire Loads, by C. J. Nuttall		AD 626 993
		U. S. Army Tank Automotive Center, Land Locomotion Lab.		
3-143	Jan 1965	Mobility Environmental Research Study One-Pass Program, by P. W. Haley		AD 467 165
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3-152	Jul 1966	One-Pass Performance of Vehicles on Fine-Grained Soils, by C. J. Nuttall, C. W. Wilson, and R. A. Werner		AD 487 446
		U. S. Army Tank Automotive Center, Land Locomotion Lab.		
3-153	Feb 1966	Mobility Environmental Research Study, Mobility Testing Procedures, by R. A. Liston, T. Czako, P. W. Haley, and others		AD 800 462
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3-154	Jun 1966	Instrumentation for Vehicle Mobility Testing in a Tropical Environment, by S. J. Clark		
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3-155	Feb 1966	A Computer Analysis of Vehicle Dynamics While Traversing Hard Surface Terrain Profiles		AD 803 194
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3-162	May 1967	Ground-Crawling: 1966; The State-of-the-Art of Designing Off-Road Vehicles, by C. J. Nuttall		AD 816 577
		Geotech, A Teledyne Company		
3-176	Aug 1967	Research, Development, and Prototype Production of an Ultraviolet Sensing Soil Moisture Meter, by J. B. Cohen		AD 837 529

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		Florida State University	
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Camp Hale, Colorado
  TM 3-414-4; MP 4-513
Camp LeJeune, North Carolina
  TM 3-240-15; MP 4-726
Camp Pickett, Virginia
  MP 4-726
Camp Shelby, Mississippi
  MP 4-726
Camp Stewart, Georgia
  MP 4-101, 4-528
Cherry Point MAS, North Carolina
  MP 4-726

Edwards Air Force Base, California
  MP 4-365
Eglin Air Force Base, Florida
  TR 3-554, 3-783-B-1, 3-783-B-2, 3-783-D, 3-783-E; MP 4-726

Fort Bragg, North Carolina
  MP 4-528
Fort Campbell, Kentucky
  MP 4-726
Fort Greely, Alaska
  MP 3-861; CR 3-22
Fort Jackson, South Carolina
  MP 4-726
Fort Knox, Kentucky
  TM-3-240-10; MP 4-726, U-3/74, M-74-6, M-74-8, M-75-5
Fort Leonard Wood, Missouri
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Fort McClellan, Alabama
  MP 4-726

Fort Polk, Louisiana
  MP M-75-3
Fort Ruckner, Alabama
  MP 4-300, 4-726
Fort Wainwright, Alaska
  TR 3-744-1

Marshall Space Flight Center, Mississippi
  TR 3-783-B-1, 3-783-B-2
Meridian Naval Air Station, Mississippi
  MP 4-726

Pine Bluff Arsenal, Arkansas
  MP 4-726
Pope Air Force Base, North Carolina
  TR 3-554

Quantico Marine Schools, Virginia
  MP 4-726

Yuma Test Station, Arizona
  TM 3-240-4, 3-240-7, 3-240-15; TR 3-588-1, 3-588-2

PART III

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3. REPORT TITLE

TRAFFICABILITY OF SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Project Title: Trafficability of Soils as Related to the Mobility of Military d. Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum - Unnumbered 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This report covers a limited investigation made to correlate data on the trafficability of soils with the mobility of standard military vehicles and to present the results as tables or charts suitable for use by the Army and the Navy. The time allotted for the study was so short that only a limited range of vehicles, soil types, and soil conditions could be tested. In addition, the accumulated data could not be subjected to thorough and complete analysis. Therefore, the information presented must not be considered as entirely accurate or final. Additional study and testing are necessary to refine the data.

KEYWORDS: Field tests; Military vehicles; Mobility; Trafficability

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1 ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a REPORT SECURITY CLASSIFICATION
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2b GROUP

3 REPORT TITLE
TRAFFICABILITY OF SOILS; PILOT TESTS--SELF-PROPELLED VEHICLES

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
First report in a series

5 AUTHOR(S) (Last name, first name, initial)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c. Project Title: Trafficability of Soils as Related to the Mobility of
d. Military Vehicles

9a. ORIGINATOR'S REPORT NUMBER(S)
Technical Memorandum No. 3-240

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
AD 108 278

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12 SPONSORING MILITARY ACTIVITY
Chief of Engineers, DA
Washington, D. C. 20315

13. ABSTRACT

This report describes part of a comprehensive study to determine the relations between the trafficability of soils and the mobility of military vehicles. The pilot tests reported here were conducted primarily to develop test procedures and techniques for full-scale tests on self-propelled vehicles. In these full-scale tests, the correlations between the readings from the instruments and the trafficability of the soils are to be developed.

KEYWORDS: Field tests; Military vehicles; Self propelled vehicles; Test procedures; Test techniques; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; LABORATORY TESTS TO DETERMINE EFFECTS OF MOISTURE CONTENT AND DENSITY VARIATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

First supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 First Supplement
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c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 279

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The tests reported here were conducted to obtain a better understanding of the effect of changes in moisture content and density on the trafficability of a soil and to obtain information on the strength and stickiness characteristics of a wide range of soils at various moisture contents and densities.

KEYWORDS: Laboratory tests; Soil adhesion; Soil density; Soil property relations; Soil moisture; Soil strength; Trafficability

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

TRAFFICABILITY OF SOILS; TRAFFICABILITY STUDIES--FORT CHURCHILL, SUMMER 1947

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Second supplement in a series

5 AUTHOR(S) (Last name, first name, initial)

Anonymous

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO. b. PROJECT NO c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Second Supplement 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 280

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

The reconnaissance studies reported here were conducted to obtain information for planning more extensive studies if needed. The studies also furnish information on conditions (both soil and terrain) which are quite different from any previously tested.

KEYWORDS: Field tests; Muskeg; Trafficability; [Fort Churchill, Canada]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE
TRAFFICABILITY OF SOILS; DEVELOPMENT OF TESTING INSTRUMENTS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Third supplement in a series

5 AUTHOR(S) (Last name, first name, initial)
Anonymous

6 REPORT DATE October 1948	7a. TOTAL NO OF PAGES 131	7b NO. OF REFS 0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Project Title: Trafficability of Soils as Related to the Mobility of d Military Vehicles	9a ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Third Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 451

10 AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT
The tests reported here were conducted to develop the cone penetrometer and the stickiness indicator for use in predicting soils trafficability. In addition, this report describes studies conducted to develop a soil sampler for obtaining density samples and an electrically operated dynamometer for measuring drawbar pulls. The problem of an instrument for measuring slipperiness was studied, and a method for rapidly predicting the moisture content with respect to the liquid and plastic limits was investigated. The report summarizes the status of instrumentation for soil trafficability studies as of the date of the report.

KEYWORDS: Cone penetrometers; Dynamometers; Soil samples; Trafficability test instruments

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Security Classification

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DOCUMENT CONTROL DATA - R&D

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; TESTS ON SELF-PROPELLED VEHICLES, YUMA, ARIZONA, 1947

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Fourth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Project Title: Trafficability of Soils as Related to the Mobility of Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Fourth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 452

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The trafficability project calls for conducting full-scale field tests with representative self-propelled and towed vehicles to obtain data to correlate cone index, slipperiness, and stickiness with soil trafficability. Tests in controlled conditions were scheduled for five soil types ranging from a coarse sand to a plastic clay. Three of the soils were found near Yuma, Ariz., and two were found near Vicksburg, Miss. This report describes the tests conducted with self-propelled vehicles in the three Yuma soils.

KEYWORDS: Desert regions; Field tests; Military vehicles; Sands; Self propelled vehicles; Trafficability; [Yuma, Arizona]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; ANALYSIS OF EXISTING DATA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Fifth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Fifth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 453

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This report presents the findings of a study and analysis of available data (published by various agencies of the United States, British, and Canadian Governments during the period 1943-1947) on the trafficability of soils so that future trafficability studies would be directed in the most fruitful channels. The existing data are reviewed, an analysis is presented of the factors that affect the trafficability of a soil, and an approach to the problem of developing instruments and techniques for measuring soil properties for use in predicting the trafficability of a specific area is given. The problem of soil classification also is discussed. In addition, a glossary of trafficability terms and a bibliography are appended for reference purposes.

KEYWORDS: Bibliographies; Glossaries; State-of-the-art studies; Trafficability; Trafficability data

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; TESTS ON SELF-PROPELLED VEHICLES, VICKSBURG, MISSISSIPPI, 1947

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Sixth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1949	215	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Project Title: Trafficability of Soils as Realted to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Sixth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 038 092

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The trafficability project calls for conducting full-scale field tests with representative self-propelled and towed vehicles to obtain data to correlate cone index, slipperiness, and stickiness with soil trafficability. Tests in controlled conditions were scheduled for five soil types ranging from a coarse sand to a plastic clay. Three of the soils were found near Yuma, Ariz., and two were found near Vicksburg, Miss. This report describes the tests conducted with self-propelled vehicles in the two Vicksburg soils.

KEYWORDS: Field tests; Fine grained soils; Military vehicles; Self propelled vehicles; Trafficability; [Vicksburg, Miss.]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
TRAFFICABILITY OF SOILS; TESTS ON TOWED VEHICLES, 1947-1948

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Seventh Supplement
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c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 454

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT
The trafficability test program calls for conducting full-scale field tests with representative self-propelled and towed vehicles to obtain data to correlate cone index, slipperiness, and stickiness with soil trafficability. Tests in controlled conditions were scheduled for five soil types ranging from a coarse sand to a plastic clay. Three of the soils were found near Yuma, Ariz., and two were found near Vicksburg, Miss. This report describes the tests conducted with towed vehicles in all five soil types.

KEYWORDS: Field tests; Fine grained soils; Military vehicles; Sands; Towed vehicles; Trafficability; [Vicksburg, Mississippi; Yuma, Arizona]

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP
3. REPORT TITLE TRAFFICABILITY OF SOILS; SLOPE STUDIES	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Eighth supplement in a series	
5. AUTHOR(S) (Last name, first name, initial) Anonymous	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-01 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Eighth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 108 455
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

It has been assumed that the methods used in predicting the ability of a vehicle to move across level terrain can be applied to gradients by a theoretical evaluation of the mechanics of the case. This report presents the results of all tests conducted to study trafficability of slopes in the current phase of the trafficability studies.

KEYWORDS: Field tests; Military vehicles; Mobility; Slope performance; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE TRAFFICABILITY OF SOILS; VEHICLE CLASSIFICATION	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Ninth supplement in a series	
5. AUTHOR(S) (Last name, first name, initial) Anonymous	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Ninth Supplement
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c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This report describes approximately 750 recorded vehicular tests of off-the-road performance of military vehicles, both self-propelled and towed, and offers a system for classifying vehicles based thereon.

KEYWORDS: Field tests; Military vehicles; Mobility; Trafficability; Vehicle classes

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFF..CABILITY OF SOILS; TESTS ON NATURAL SOILS WITH SELF-PROPELLED VEHICLES, ' 949 AND 1950

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Tenth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1954	284	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO 8-70-05-01	Technical Memorandum No. 3-240 Tenth Supplement
c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 034 076

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This report describes tests conducted with self-propelled vehicles on natural soil conditions at sites near Vicksburg, Miss., near Laurel, Miss., and at Fort Knox, Ky., during 1949 and 1950. Only fine-grained soils were included in these tests. The 1949 test program was in the nature of a pilot study and was conducted to determine whether the criteria established for controlled soil conditions apply to natural soil conditions, or whether a wide program of tests on natural soil conditions would be needed, and to devise new test procedures, methods, and techniques, and new criteria if additional tests were found necessary. The tests conducted in 1950 utilized techniques of testing and correlation developed or indicated in the 1949 tests and provided additional information concerning the effects of traffic on the strength of natural soils. A descriptive account of the testing program and the test data obtained, and an analysis of the results are presented in this report.

KEYWORDS: Field tests; Fine grained soils; Military bases; Military vehicles; Self propelled vehicles; Soil strength; Trafficability; [Fort Knox, Kentucky; Laurel, Mississippi; Vicksburg, Mississippi]

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Unclassified

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	Unclassified
	2b GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; SOIL CLASSIFICATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Eleventh supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1954	26	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 8-70-05-001	Technical Memorandum No. 3-240 Eleventh Supplement
c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Superseded by Technical Memorandum No. 3-240, Sixteenth Supplement, with same title.	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The purpose of this study was to produce means of estimating the trafficability of soils according to their identification in the Unified Soil Classification System described in Waterways Experiment Station Technical Memorandum No. 3-357, "The Unified Soils Classification System," dated March 1953. The study was limited mainly to the analysis of trafficability tests conducted since 1945 by the Waterways Experiment Station.

KEYWORDS: Soil strength; Statistical analysis; Trafficability classification

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Unclassification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
TRAFFICABILITY OF SOILS; TESTS ON NATURAL SOILS WITH SELF-PROPELLED VEHICLES, 1951-1953

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Twelfth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Twelfth Supplement
b. PROJECT NO. 8-70-05-001	
c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 052 206

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The tests described in this report were conducted with several self-propelled vehicles without tow loads on natural fine-grained soils at a number of sites during the years 1951, 1952, and 1953. Similar tests conducted in 1949 and 1950 with only two vehicles on natural fine-grained soils, having plasticity indexes less than about 20 or greater than about 38, had permitted the development of instruments and techniques for measuring the trafficability of a fine-grained soil and predicting the performance of a vehicle on it. The purpose of the tests reported herein was to verify the soil parameter-vehicle performance relations previously established, by additional testing with other vehicles on a wider range of soils. The integrity of formulas for computing vehicle cone indexes, the minimum soil strength required for the operation of vehicles, was also verified.

KEYWORDS: Field tests; Fine grained soils; Military vehicles; Self propelled vehicles; Trafficability; Vehicle cone index

DD FORM 1 JAN 64 1473 Unclassified

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; PILOT STUDY, TESTS ON COARSE-GRAINED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Thirteenth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.
Palmer, H.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1955	186	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-001 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Thirteenth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 082 187

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This is an account of the first major attempt by the Waterways Experiment Station to correlate vehicle performance with measured properties of coarse-grained soils. Purpose of field testing was (a) to become intimate with mobility problems on coarse-grained soils and (b) to determine whether instruments and techniques that had been successful for defining trafficability of fine-grained soils would also be successful in coarse-grained soils. In more than 300 tests using 18 vehicles at 17 locations, 11 of which were beaches, it is demonstrated that four instruments are capable of making measurements in sands which can be correlated with slope-climbing ability of trucks when cognizance is taken of tire pressure, with about 85 percent accuracy. Of the four instruments, the cone penetrometer is selected for future studies because of its ability to determine subsurface conditions and because it also is used for fine-grained soils.

KEYWORDS: Beach trafficability; Coarse grained soils; Field tests; Military vehicles; Mobility; Trafficability; Trafficability test instruments

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; A SUMMARY OF TRAFFICABILITY STUDIES THROUGH 1955

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Fourteenth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-100, Mobility of the Army c. Subproject: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Fourteenth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 121 975

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The trafficability factors, bearing and traction capacity, are functions of shearing strength. A simple instrument, the cone penetrometer, measures an index of shear strength. Cone indexes on fine-grained soils and sands with fines, poorly drained, are related to vehicle performance, but an auxiliary test, remolding, must accompany the cone penetrometer test to predict changes in cone index under traffic. Slipperiness and stickiness cannot be measured, but can be anticipated approximately from simple soil tests. Tests with wheeled vehicles on sands showed fair correlation between maximum slope and cone index with tire pressure duly considered. Means are presented for: classifying soils from the trafficability standpoint; computing cone index required for any military vehicles; quickly estimating maximum slopes vehicles can climb, maximum tow loads, and towing forces required on various soil strengths; making actual trafficability measurements and mapping them for strategic and tactical purposes; and for estimating trafficability without contact with the soil.

KEYWORDS: Military vehicles; Mobility; Soil strength; State-of-the-art studies; Trafficability; Trafficability classification; Trafficability mapping; Trafficability prediction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; TESTS ON COARSE-GRAINED SOILS WITH SELF-PROPELLED AND TOWED VEHICLES, 1956 AND 1957

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Fifteenth supplement in a series .

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Fifteenth Supplement
b. PROJECT NO. c. Subproject No. 8-70-05-400; Trafficability of Soils as Related to the d. Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 218 089

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Sponsored in part by U. S. Navy Bureau of Yards and Docks	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Self-propelled, towing, and towed tests of several military vehicles were conducted on coarse-grained soils to correlate vehicle performance with strength (cone index) and moisture condition of the soil, and vehicle characteristics. Vehicle performance for self-propelled vehicles is expressed in terms of immobilizations and nonimmobilizations and ability to pull drawbar loads; for towed vehicles, in terms of towing-force requirements. Single self-propelled wheeled vehicles were tested on undisturbed coral and volcanic sands on Pacific islands, and on quartz sand (desert and beach) in the United States. Towing tests were conducted on harrowed sand at Yuma, Ariz.; towed-vehicle tests were conducted on disturbed and undisturbed sand at Camp Lejeune, N. C. Principal conclusions are: (a) performance of single self-propelled vehicles can be expressed in cone index-slope climbing ability terms; (b) wet sands are more trafficable than dry-to-moist sands; (c) towing ability on harrowed sand slopes can be computed with reasonable accuracy from measurements obtained on level harrowed sand; and (d) towing-force requirements of wheeled trailers can be correlated with cone index and tire pressure.

KEYWORDS: Beach trafficability; Coarse grained soils; Desert regions; Field tests; Military bases; Military vehicles; Mobility; Self propelled vehicles; Towed vehicles; Trafficability; [Camp Lejeune, N. C.; Pacific Islands; Yuma, Ariz.]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b GROUP

3. REPORT TITLE
TRAFFICABILITY OF SOILS; SOIL CLASSIFICATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Sixteenth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)
Meyer, M. P.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Sixteenth Supplement
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c. Subproject No. -02 Surface Mobility (Trafficability)	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	AD 265 743

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
This report supersedes Technical Memorandum No. 3-240, Eleventh Supplement, August 1954	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A statistical analysis was made of soil strength (cone index, remolding index, and rating cone index), soil moisture, dry density, and percent saturation for soils classified according to the Unified Soil Classification System (USCS) and U. S. Department of Agriculture (USDA) classification system. Data were obtained during wet-season periods from more than 1300 sites located principally in humid, temperate regions of the United States. Soils of high- and low-topography positions were analyzed for average and high-moisture conditions in the wet season. The information was used to improve an existing scheme for classifying soils according to their trafficability. A comparison of USCS and USDA soil types was made for the 6- to 12-in. layer of soils, and a study was made to compare the type of soil in the 0- to 6-in. layer with the type in the 6- to 12-in. layer of the profile, in USDA terms. Two appendices describe data sources and test procedures.

KEYWORDS: Soil strength; Statistical analysis; Trafficability classification; Trafficability data

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3 REPORT TITLE

TRAFFICABILITY OF SOILS; TESTS ON COARSE-GRAINED SOILS WITH SELF-PROPELLED AND TOWED VEHICLES, 1958-1961

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Seventeenth supplement in a series

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.

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8a CONTRACT OR GRANT NO.	9a ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Seventeenth Supplement
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10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Sponsored in part by U. S. Navy Bureau of Yards and Docks	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

Standard trafficability and special tests with 21 military vehicles were conducted on coarse-grained soils. Areas of investigation included: (a) the correlation of slope-climbing and towing-force data; (b) effects of tire size, traction devices, tire treads, and wheel load; (c) vehicle performance on "honeycomb" sand; and (d) trafficability of gravel beaches. Self-propelled wheeled and tracked vehicles and one towed vehicle were tested at five locations in the United States and France. Principal conclusions were: (a) maximum towing force of self-propelled wheeled vehicles on level sand was about 2 percent greater than maximum slope negotiable; (b) vehicle performance increased with decreases in ground-contact pressure; (c) vehicle performance was better with smooth tires than with treaded tires or the traction device tested; and (d) vehicle performance on wet sand that tended to liquefy under the vehicle load (honeycomb sand) was similar to that on fine-grained soils.

KEYWORDS: Beach trafficability; Coarse grained soils; Field tests; Military vehicles; Self propelled vehicles; Slope performance; Tires; Towed vehicles; Traction devices; Trafficability; [France]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SOILS; DEVELOPMENT OF REVISED MOBILITY INDEX FORMULA FOR SELF-PROPELLED WHEELED VEHICLES IN FINE-GRAINED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Eighteenth Supplement

5. AUTHOR(S) (First name, middle initial, last name)

James G. Kennedy
Edgar S. Rush

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046 c. Task 02 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Eighteenth Supplement 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 832 912

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

In 1955, formulas for computing mobility indexes (MI) and converting them to vehicle cone indexes (VCI), or minimum soil strength required for 50-pass go-no go, for current military wheeled and tracked vehicles were reported. Subsequent trafficability tests with vehicles having construction-equipment-type tires showed that the computed VCI did not agree closely with test results. To obtain data to determine whether the MI formula for self-propelled wheeled vehicles needed modification, field tests were run with small vehicles equipped with large, high-flotation tires, very large vehicles with very heavy wheel loads, and a few conventional vehicles. Main test purposes were to obtain data to determine experimentally 50-pass VCI for some untested vehicles and from these and other test results develop an MI formula for a wide range of vehicle weights and tire sizes. Although only 16 vehicles were tested, VCI's were determined for 20 vehicle "types." To determine if VCI prediction could be improved, a statistical analysis was made on both the original and revised MI formulas using a multiple linear regression technique. General conclusions are that considerable improvement can be made in the original formula merely by using the multiple regression equation; further improvements can be made by using the revised formula; use of the revised multiple regression formula provides only slight improvement over use of the revised formula. Thus, it is suggested that the revised formula be adopted. Appendix A gives the original and revised MI formulas and compares computed VCI's for some standard and experimental vehicles using the two formulas. Appendix B is a detailed analysis and evaluation of the original and revised MI formula factors by the multiple linear regression technique.

KEYWORDS: Field tests; Fine grained soils; Military vehicles; Self propelled vehicles; Trafficability; Vehicle cone index

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
TRAFFICABILITY OF SOILS; Nineteenth Supplement, EFFECTS OF SURFACE CONDITIONS ON DRAWBAR PULL OF A WHEELED VEHICLE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Nineteenth Supplement

5. AUTHOR(S) (First name, middle initial, last name)
Edgar S. Rush
James H. Robinson

6. REPORT DATE
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9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT
Tests were conducted with one wheeled vehicle to determine effects of soil surface conditions on drawbar pull and to relate optimum drawbar pull to soil strength as measured by a number of instruments. One hundred and six drawbar pull-slip tests were conducted with an M37 3/4-ton truck at a gross weight of 7240 lb. One tire size (9.00-16, 8-PR), two tread patterns (smooth and nondirectional military), and two tire deflections (15% and 35%) were tested. Surface conditions varied from dry and firm to wetted with small amounts of water to flooded. Asphalt surfaces also were tested. Measurements of soil strength were made with the standard cone penetrometer, multiprobe penetrometer, sheargraph, soil truss, and friction wheel. Analysis of data indicated that the multiprobe penetrometer and sheargraph show the most promise as instruments for measuring surface conditions and predicting vehicle performance. Equations were developed for predicting drawbar pull based on deflection and soil measurements with the sheargraph and multiprobe penetrometer.

KEYWORDS: **Drawbar pull; Field tests; Soil strength test instruments; Surface soil strength; Trafficability; Wheeled vehicles; [M37 3/4-ton truck]**

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3 REPORT TITLE

TRAFFICABILITY OF SOILS, DEVELOPMENT OF VEHICLE PERFORMANCE PREDICTION EQUATIONS AND CLASSIFICATION SYSTEM FOR COARSE-GRAINED SOILS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Twentieth Supplement

5 AUTHOR(S) (First name, middle initial, last name)

James J. Kennedy

6 REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
April 1974	74	9

8a CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-240 Twentieth Supplement
b. PROJECT NO 1T162103A046	
c Task 02	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10 DISTRIBUTION STATEMENT

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13 ABSTRACT

This report presents techniques for estimating vehicle performance capabilities in coarse-grained soils (clean sands) and a scheme for classifying dry-to-moist sands for trafficability purposes. Earlier test programs showed a need for separation of sand into two categories wet sand and dry-to-moist sand. Dry-to-moist sands only are presented in this report, since wet sand is usually temporary, making wet-sand strength a time-dependent variable difficult to correlate with vehicle performance. Equations are derived for predicting the performance of all-wheel-drive wheeled vehicles based on sand strength (cone index), tire characteristics (inflation pressure, sizes, etc), and gross vehicle weight. Performance parameters are maximum slope negotiable, maximum drawbar pull (maximum towing force), and minimum sand strength required for a vehicle to negotiate level sand (vehicle cone index). An equation is also derived for predicting motion resistance for wheeled vehicles (self-propelled type or towed trailers). The only variables in this equation are cone index and tire inflation pressures. For tracked vehicles, equations are derived for predicting maximum towing force and motion resistance. For the range of sand strengths investigated, cone index does not affect performance, so the only variables considered are gross vehicle weight and track type (rigid as on engineer tractors or flexible as on high-speed tractors). As a result of the statistical studies performed to develop a sand classification system for trafficability purposes, the following conclusions are drawn (a) performance of a given vehicle is the same (requires the same cone index for a given slope) regardless of sand type (quartz, coral, or volcanic) or environment (beach or desert), and (b) frequency of occurrence of cone index by type and environment shows that quartz sand is the strongest and coral sand is the weakest, and beach sands are stronger than desert sands (quartz only). Appendix A presents documentation of the derivation and evaluation of the wheeled vehicle performance equations used in the first-generation AMC Ground Mobility Model.

KEYWORDS: Coarse grained soils; Military vehicles; Performance predictions; Sands; Trafficability; Trafficability classification

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3. REPORT TITLE
FORECASTING TRAFFICABILITY OF SOILS; METEOROLOGICAL AND SOIL DATA, VICKSBURG, MISSISSIPPI, 1948-1949

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-01 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331 Report No. 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT
The investigation of soils trafficability as related to mobility of military vehicles is divided into three phases as follows: (1) soils classification and trafficability data or the development of methods and instruments for determination of trafficability by ground reconnaissance parties; (2) soils trafficability predictions or the development of methods to correlate soils trafficability with weather data sufficiently accurate to enable military planners to forecast the trafficability of soils in an area without physical tests; and (3) crossing areas of mud, sand, or unstable terrain or the development of portable roadways and construction of roadways from local and other materials for crossing very soft areas. The Waterways Experiment Station has been assigned investigation of the first two phases. This report describes the first studies conducted under phase (2), based upon the following premise: both the cone index and the stickiness vary primarily with moisture content; therefore, a correlation between these factors and climate appears in order if forecasts of soil trafficability are to be made.

KEYWORDS: Meteorological data; Soil data; Soil moisture prediction; Trafficability prediction; [Vicksburg, Mississippi]

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3. REPORT TITLE
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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-01 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331 Report No. 2 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
U. S. Forest Service collaborated in this study.	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This is a continuation of the study started and reported upon in Report No. 1 of this series of reports. Many valuable suggestions for refining the forecasting techniques presented in that report are incorporated in this one.

KEYWORDS: Meteorological data; Soil data; Soil moisture prediction; Trafficability prediction; [Vicksburg, Mississippi]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

FORECASTING TRAFFICABILITY OF SOILS; THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 3 of a series; three volumes and an appendix

5 AUTHOR(S) (Last name, first name, initial)

Anonymous

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10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
U. S. Forest Service collaborated in this study.	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

This is a continuation of the study reported upon the first two reports of this series. It comprises three volumes and an appendix. Volume 1, prepared jointly by the Waterways Experiment Station and the U. S. Forest Service, gives a summary and comparison of prediction methods, and an account of current work and that planned for the future. Detailed descriptions of the Forest Service prediction methods and experimental procedures used at Vicksburg are given in volume 2. Predictions developed by the Forest Service for other areas are given in volume 3 together with results of correlation studies and a description and application of the Waterways Experiment Station prediction system. Results of special studies and basic soil-moisture and weather data are presented in the appendix.

KEYWORDS: Meteorological data; Soil data; Soil moisture prediction; Trafficability prediction; [Vicksburg, Mississippi]

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3. REPORT TITLE FORECASTING TRAFFICABILITY OF SOILS: INFORMATION FOR PREDICTING MOISTURE IN THE SURFACE FOOT OF VARIOUS SOILS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 4 of a series.	
5. AUTHOR(S) (Last name, first name, initial) Carlson, C. A. Horton, J. S.	

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10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES U. S. Forest Service collaborated in this study.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Site characteristics, soil properties, climate, and all information needed for soil-moisture predictions from the 131 sites, representing a wide variety of American soils, used in development of the soil-moisture prediction method are given. Accuracy of the prediction method was tested for every site by comparing predicted moisture contents to actual soil-moisture records. Sixty-five sites for which deviations were computed for every day had an average deviation of 0.03 in. of moisture for the 0- to 6-in. layer and 0.06 in. for the 6- to 12-in. layer. Deviations for 45 sites with comparisons of only before- and after-storm moisture contents averaged 0.13 in. and 0.10 in. for the two layers. As a second method of comparison, prediction relations developed from one year's record were used to predict soil-moisture content for the next year. Generally, deviations of predicted from actual for the second year averaged about the same as for the first year. Present status of the project and recommendations for future studies are outlined.

KEYWORDS: Soil data; Soil moisture prediction; Trafficability prediction

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3. REPORT TITLE
FORECASTING TRAFFICABILITY OF SOILS; DEVELOPMENT AND TESTING OF SOME AVERAGE RELATIONS FOR PREDICTING SOIL MOISTURE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Carlson, C. A.
Horton, J. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
U. S. Forest Service collaborated in this study.	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Detailed observations made in previous studies of sites distributed throughout the United States were used to derive average soil-moisture relations for use in applying previously developed soil-moisture content prediction methods to sites for which no specific data on the moisture regime are available. The average relations were tested on 24 sites that had been used in the development of prediction method, on 10 sites for which soil strength and moisture data were available, and on 617 sites located throughout the United States for which detailed data were not available. Predicted and measured values were compared, and the accuracy of prediction of soil moisture was within reasonable limits of error for well-drained soils. Appendices give the prediction method developed and a sample of its application, describe the 617 sites with limited data used in this investigation, and present results of special studies made to improve the accuracy of the prediction method.

KEYWORDS: Soil data, Soil moisture prediction; Trafficability prediction

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP
3 REPORT TITLE FORECASTING TRAFFICABILITY OF SOILS: AIRPHOTO APPROACH	
4 DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 6 of a series; two volumes	
5 AUTHOR(S) (Last name, first name, initial) Rula, A. A. Grabau, W. E. Miles, R. D.	

6 REPORT DATE June 1963	7a TOTAL NO OF PAGES 342	7b NO OF REFS 31

8a CONTRACT OR GRANT NO. DA-22-079-eng-59 with Purdue University b PROJECT NO 1-T-0-21701-A-046, Trafficability and Mobility Research c Task -02, Surface Mobility d	9a ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331 Report No. 6, Vols 1-2 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 409 916 (Vol 1), AD 410 212 (Vol 2)
10 AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11 SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT The study reported herein is part of a comprehensive effort, begun in 19?9 to develop techniques for estimating the trafficability of soil by remote means. It is devoted specifically to development of techniques for analyzing and interpreting vertical aerial photographs for soil trafficability purposes. To provide a basis for this study, airphoto and soil trafficability data were collected over a period of several years by Purdue University and Waterways Experiment Station personnel from 33 humid-climate states and 2 arid-climate states in the United States. This report describes the principles and procedures of airphoto interpretation required to estimate the trafficability of soils, and summarizes data reported previously in supplemental reports in a form suitable for use by personnel engaged in airphoto-trafficability analysis. Soil factors, slope factors, and obstacle factors all pertinent to terrain trafficability, are discussed. Terrain is classified into various representative landscapes which are fully described in regard to regional drainage, topography, local erosion, natural vegetation, cultural practices, parent material, soil profile, and trafficability and cross-country movement characteristics. Procedures for airphoto analysis of trafficability are rigidly defined, and an example of photo interpretation is given. Pertinent photographs, data tabulations, and appendices are presented in Volume II of this report. Appendix A lists the locations in which the soil and trafficability tests of this study were conducted. Appendix B presents a summary of the soil and site data obtained from these tests. Appendix C comprises nine generalized landscape-parent material maps, showing world-wide geographic occurrence of each representative landscape type.
KEYWORDS: Airphoto interpretation; Trafficability predi. ion

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

FORECASTING TRAFFICABILITY OF SOILS; A PILOT STUDY OF SOILS SUBJECTED TO FREEZING AND THAWING

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 7 of a series

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Smith, N. H.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
June 1964	71	78

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331 Report 7
b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research Task No. -02, Surface Mobility d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 450 626

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Moisture content, density, and soil strength data were obtained from two test areas in Michigan which are subject to periods of freezing. Each area contained three plots with different vegetation cover: bare, herbaceous, or hardwood. Meteorological data from neighboring weather stations were recorded. Analysis of data showed that (a) the greater the vegetation density, the later the date of the first frost's appearance; (b) the greater the vegetation density and snow cover depth, the less the mean frost depth; (c) soil moisture content increased significantly as frost depth increased, and decreased when frost depth decreased; (d) soil density followed a trend opposite to that of moisture content; (e) soil strength increased radically when soil was frozen; and (f) soil strength was lowest during and immediately after the final thawing period of the season.

KEYWORDS: Freeze-thaw; Soils; Trafficability; Trafficability prediction

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

FORECASTING TRAFFICABILITY OF SOILS: Report 8, VARIABILITY OF PHYSICAL PROPERTIES OF LOESS SOILS, WARREN COUNTY, MISSISSIPPI

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 8 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Charles A. Carlson
Alvin R. McDaniel

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1967	77	11

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331, Report 8
b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research	
c. Task -02, Surface Mobility	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This study was to determine if the average of soil strength values obtained in a small area can be reliably applied to larger areas. Values of properties used in predicting soil strength and classifying soils were compared for areas differing in size. Six test sites in each of four loessial soil series were established, using series boundaries on soil survey maps to locate the sites. The series were Memphis and Loring in the uplands and Collins and Falaya in the bottomlands. Each site had five sampling rows; each row had four sampling positions. Plots of pedologically distinct soil series were identified from field examination within sites and were used as an additional subdivision of test areas. Soil strength and moisture content data were collected on four visits, other physical property data on one visit. The four series could not be distinguished by soil strength because the cone indexes (CI's) varied widely for any one series and the range of CI for each series was about the same. Soils of the 6- to 12-in. layer of the uplands differed from those of the bottomlands in clay content and plasticity, but not in strength. The poorly drained Henry series and alluvial-fill soils of the uplands, as identified in the field, had the lowest CI's. Certain plots exhibited consistently different CI's for each visit than did other plots in the same series, and certain rows in the same plot showed consistently different CI's. These differences could not be explained satisfactorily in terms of soil series, or soil properties commonly used in the Unified Soil Classification System and the U. S. Department of Agriculture textural classification. Appendix A. includes basic data for each site.

KEYWORDS: Loess; Soil property variations; Soil strength; Trafficability; Trafficability prediction, [Vicksburg, Mississippi]

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

FORECASTING TRAFFICABILITY OF SOILS; WATER TABLE STUDY AT CROSSETT, ARKANSAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 9 of a series

5. AUTHOR(S) (First name, middle initial, last name)

John R. Bassett
Marvin P. Meyer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1968	98	44

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331, Report 9 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 838 517

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Conducted in cooperation with the U. S. Forest Service, U. S. Department of Agriculture.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The purpose of the study was to determine and evaluate soil, site, and weather factors that affect high water tables, and to explore means by which an existing method for predicting soil-moisture content of the 0- to 6-in. and 6- to 12-in. layers could be modified to improve its accuracy when applied to soils with high water tables. Factors that significantly affected the initiation, duration, and periodicity of high water tables were precipitation, topographic position, depth to a relatively impermeable soil layer, slope of ground, rate of evapotranspiration, and, where applicable, stream or river stage. A scheme for predicting daily depths to water tables was incorporated in the soil-moisture prediction method, resulting in reasonably accurate predictions of soil moisture content and soil strength.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Water table prediction; [Crossett, Arkansas]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
FORECASTING TRAFFICABILITY OF SOILS; RELATIONS OF STRENGTH TO OTHER PROPERTIES OF FINE-GRAINED SOILS AND SANDS WITH FINES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 10 of a series

5. AUTHOR(S) (First name, middle initial, last name)
John G. Collins

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
July 1971	120	13

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-331 Report 10
b. PROJECT NO 1-T-0-62103-A-046 and 1-T-0-62112-A-131	
c. Task 02	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 728 814
d.	

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT Attempts were made to establish relations between cone index, rating cone index, and remolding index (penetrometer strength measures commonly used in soil trafficability studies) and moisture content, soil separates contents, Atterberg limits, organic matter content, and dry density. Analyses were based on 6- to 12-in. soil layer data from 95 widely varying soils. In general, the approach followed in analyzing data was to (a) express the relation between a measure of strength and moisture content for each site with one standard equation form, (b) select coefficients that would define the strength-moisture relation for each site, and (c) relate the coefficients to soil properties. Results of the analyses indicate that usually (a) strength decreases with an increase in moisture for a given soil, (b) at a given strength level moisture content increases with a decrease in grain size or an increase in plasticity but is not associated with changes in organic matter content or dry density, (c) at a given moisture content changes in strength are associated primarily with changes in clay and/or sand contents when the U. S. Department of Agriculture soil separates are considered and with plastic and/or liquid limits when the Atterberg limits are considered, and (d) the predictive power of derived strength relations is poor even though the relations are significant (5% level). Appendixes are included in which the basic data and procedures used in obtaining the data are presented.

KEYWORDS: Fine grained soils; Soil property relations; Soil strength prediction; Trafficability prediction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
TRAFFICABILITY OF SNOW; VEHICLES IN SNOW: A CRITICAL REVIEW OF THE STATE OF THE ART

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 1 in a series

5. AUTHOR(S) (First name, middle initial, last name)
C. J. Nuttall, Jr.
J. P. Finelli

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1955	71	206

8a. CONTRACT OR GRANT NO. DA-22-079-eng-159	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-414, Report 1
b. PROJECT NO. 8-70-05-001	
c. Trafficability of Soils as Related to the Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) Stevens Institute of Technology, Report No. 553
d.	

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA, Washington, D. C. 20315

13. ABSTRACT
A desk study is reported which reveals that little knowledge exists in the field of relating snow conditions to vehicle performance, and that there are several vehicles and vehicle concepts capable of providing good over-snow transport. The study argues the necessity for fundamental-type research into vehicle-snow relationships by coordinated efforts of snow scientists, trafficability and mobility researchers, and automotive engineers.

KEYWORDS: Bibliographies; Mobility; Snow trafficability; State-of-the-art studies

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TRAFFICABILITY OF SNOW; GREENLAND STUDIES 1954

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 2 in a series

5. AUTHOR(S) (Last name, first name, initial)
Rula, A. A.
Knight, S. J.
Rush, E. S.

6. REPORT DATE
August 1955

7a. TOTAL NO. OF PAGES
197

7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 8-70-05-001

c. Trafficability of Soils as Related to the Mobility of Military Vehicles

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
Technical Memorandum No. 3-414
Report 2

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
AD 082 188

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Chief of Engineers, DA
Washington, D. C. 20315

13. ABSTRACT

An account of tests conducted with a number of vehicles at three locations in Greenland during the summer of 1954 is presented. All data are shown. Instruments and techniques successful in the measurement of the trafficability of fine-grained soils and the prediction of vehicle performance were used (with minor modifications) in the Greenland snow. Results are inconclusive because snow in Greenland did not provide mobility problems. Results were nevertheless encouraging.

KEYWORDS: Arctic regions; Field tests, Military vehicles; Mobility; Snow trafficability; [Greenland]

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TRAFFICABILITY OF SNOW; GREENLAND STUDIES, 1955 AND 1957

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 3 in a series

5. AUTHOR(S) (Last name, first name, initial)
Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1960	172	0

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c. Subproject No. 8-70-05-400; Trafficability of Soils as Related to Mobility of Military Vehicles

9a. ORIGINATOR'S REPORT NUMBER(S)
Technical Memorandum No. 3-414
Report No. 3

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
AD 239 552

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Chief of Engineers, DA
Washington, D. C. 20315

13. ABSTRACT
Self-propelled, towing, and towed tests were conducted with several wheeled and tracked military vehicles on a variety of fine-grained and wet coarse-grained snow conditions. The 1955 tests were conducted at various sites on or adjacent to a 220-mi-long, marked trail leading from the edge out onto the ice cap; the 1957 tests were all run at mile 30 on this route. Objectives of the study were to (a) correlate vehicle performance with snow-property measurements, (b) select an instrument that will measure snow trafficability and also meet military specifications, and (c) distinguish snow conditions that permit a vehicle to travel from those that do not. Vehicle performance was correlated with ten methods of measuring snow properties; cone index provided the best correlation. All instruments for obtaining snow-property data were serviceable, but some were more efficient than others. The snow conditions prevailing during the test periods did not produce sufficient immobilizations to establish trafficability limits.

KEYWORDS: Arctic regions; Field tests; Military vehicles; Mobility; Snow trafficability; [Greenland]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY OF SNOW; TESTS ON SUBARCTIC SNOW

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 in a series

5. AUTHOR(S) (Last name, first name, initial)

Blackmon, C. A.
Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1950	160	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 3-414 Report No. 4
b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 266 508

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A total of 39 self-propelled tests were run with tracked and wheeled vehicles at Boulder, Colorado; Fort Churchill, Manitoba, Canada; Kapuskasing, Ontario, Canada; and Houghton, Michigan. In addition, 27 self-propelled, 24 towing, and 3 towed tests were conducted with tracked vehicles at Camp Hale, Colorado. It was concluded that depth of the snowpack appears to be the most important factor affecting trafficability of subarctic snow which is kept soft by the process of sublimation. It is estimated that conventional wheeled vehicles would not negotiate snow deeper than about 25% of the wheel diameter. Snow depth is correlated with vehicle-performance parameters such as rut depth and maximum drawbar pull. It was found that (a) ground-contact pressure is the most important vehicle characteristic affecting vehicle performance, and (b) drawbar pull is greater in moist than in dry snow for snowpacks of the same depth and strength. It is recommended that vehicle tests in subarctic snow be continued and that the cone penetrometer be accepted as the most practical field instrument for measuring snow trafficability.

KEYWORDS: Field tests; Military bases; Military vehicles; Mobility; Snow trafficability; Subarctic regions; [Boulder, Colo.; Camp Hale, Colo.; Ft. Churchill, Canada; Houghton, Mich.; Kapuskasing, Canada]

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1. ORIGINATING ACTIVITY (Corporate author) US Army Engineer Nuclear Cratering Group US Army Tank-Automotive Command	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
PROJECT TANK TRAP: A Field Evaluation of Nuclear Terrain Barriers

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report

5. AUTHOR(S) (First name, middle initial, last name)
Major Bernard C. Hughes, William L. Harrison, Roger Paul

6. REPORT DATE June 1969	7a. TOTAL NO. OF PAGES 83	7b. NO. OF REFS - - -
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) NCG Technical Report No. 17 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 693 817	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES N/A	12. SPONSORING MILITARY ACTIVITY N/A

13. ABSTRACT

Project TANK TRAP was conducted to determine the capability of selected tactical vehicles to traverse craters typical of those which could be produced with Atomic Demolition Munitions (ADM). The vehicles included in the test program were the M-60 Tank, M-113 Armored Personnel Carrier, and an articulated two-unit general purpose vehicle called the POLECAT. Trafficability testing of these vehicles was performed in the SCOOTER crater, the JANGLE U crater, and Pre-SCHOONER BRAVO crater. The results of the research project indicate that: (1) craters formed in dry soil by the detonation of explosives at the surface or at very shallow depths of burst (down to approximately 20 ft/kt$^{1/3.4}$) do not present significant trafficability problems to tracked tactical vehicles; (2) craters formed at or near optimum depth of burst (160 ft/kt$^{1/3.4}$) in dry soil are a trafficability obstacle to tracked tactical vehicles; and, (3) craters formed in hard rock, such as basalt, cannot be negotiated by tracked tactical vehicles without major modification of the crater and/or assistance by heavy duty equipment, either mobile or fixed.

KEYWORDS: Craters; Military vehicles; Mobility; Obstacles; Trafficability; [M-60; M-113; POLECAT]

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STUDIES OF AERIAL CONE PENETROMETER; LABORATORY STUDY OF MECHANICAL PRINCIPLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 1 of a series

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1957	36	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-100, Mobility of the Army c. Subproject 8-70-05-101, Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-462 Report No. 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 138 265

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A specially designed spring-impact type aerial cone penetrometer was shot from a compressed air gun into a container of soil. Penetrometer velocities and soil strengths were varied over a wide range. From the data collected relationships between penetrometer action and soil properties were determined and used to compute spring deflection necessary to fire the penetrometer cartridge in soil of specified strength. The spring was then set for specific soil strengths and tests made to verify the accuracy of the settings. Results of the limited tests indicated: Cone index has a major influence on action of the aerial penetrometer in soil; the relationships among velocity, deceleration, impact of the penetrometer, and cone index of the soil appear to be consistent and reasonable; the consistent relationships permitted computation of spring size and deflection for proper indication of specified soil strength. Actual tests verified the accuracy of the computations.

KEYWORDS: Aerial cone penetrometers; Laboratory tests; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

STUDIES OF AERIAL CONE PENETROMETER; FIELD TESTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 1958	40	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-462, Report No. 2
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c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	AD 161 067

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA, Washington, D. C. 20315

13. ABSTRACT

A limited field test program demonstrated that soil penetration by the aerial cone penetrometer accomplished some softening or remolding of fine-grained soils in the immediate vicinity of the penetrometer. Curves of penetration of the aerial cone penetrometer versus rating cone index (the measure of the trafficability of a fine grained soil) appeared to be valid, indicating that the aerial penetrometer shows promise as an instrument for remotely measuring soil trafficability.

KEYWORDS: Aerial cone penetrometers; Field tests; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE STUDIES OF THE AERIAL CONE PENETROMETER; FIELD TESTS IN FINE-GRAINED SOILS, 1960	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 3 in a series	
5. AUTHOR(S) (Last name, first name, initial) Hinckmon, C. A. Knight, S. J. Rone, C. L.	
6. REPORT DATE August 1963	7a. TOTAL NO. OF PAGES: 39 — 7b. NO. OF REFS: 0
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-462 Report 3 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 450 613
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

An aluminum aerial cone penetrometer was shot from an air gun into the soil at 10 test sites encompassing four soil types and a wide range of soil conditions. Results of 73 tests conducted during the winter of 1960-61 revealed that, in addition to soil strength, soil type and plasticity appear to influence the depth of penetration of the aerial penetrometer. Curves of penetration versus three expressions of soil strength commonly used in trafficability studies (cone index and rating cone index to the depth of penetration, and rating cone index in the 6- to 12-in. layer) were developed for three soil groups, arranged according to low-, medium-, and high-plasticity index. It was concluded that several penetrations should be made in a given area to determine an average penetration to represent the strength of that area. It is recommended that additional tests be made to explore more fully the usefulness and limitations of the aerial penetrometer.

KEYWORDS: Aerial cone penetrometers; Field tests; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

STUDIES OF AERIAL CONE PENETROMETER; Report 4, IMPACT VELOCITY-IMPACT FORCE INVESTIGATIONS, 1968

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of a series

5. AUTHOR(S) (First name, middle initial, last name)

James G. Kennedy

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

An aerial cone penetrometer was dropped from heights of 50, 100, 150, 200, 241, 280, and 560 ft to determine its velocity at impact with the ground surface. A high-speed motion picture camera recorded the flight of the penetrometer just prior to impact. Velocity was determined by viewing the movie film with a motion analyzer. A hyperbolic curve defines the impact velocity-height relation of the penetrometer used in this study throughout the range of drop heights listed above. A statistical equation for the curve was developed from a relation established between height and velocity. The equation permits computation of impact velocity in terms of height of drop. Statistical techniques were used to evaluate the reliability of the equation. It was concluded from the analysis that the equation can be extrapolated to a height of 1000 ft (440 ft greater than the maximum measured height). The angle formed between the tail vanes on the penetrometer barrel during flight affects the impact velocity inversely; as vane angle increases velocity decreases. A variation of vane angle of 43 deg produces a variation in impact velocity of approximately 5.0 fps and in impact force of 5 lb. This variation would produce little if any effect on spring deflection and no effect on the ability of the firing mechanism of the penetrometer to indicate the preselected soil strength upon impact. It is recommended that 600 ft be established as the minimum height from which the penetrometer be dropped. Previously determined theoretical impact forces were verified.

KEYWORDS: Aerial cone penetrometers, Field tests; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

DEFLECTION OF MOVING TIRES; A PILOT STUDY ON A 12X22.5 TUBELESS TIRE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (Last name, first name, initial)

Green, A. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-516 Report No. 1
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c. Subproject No. 8-70-05-400, Trafficability of Soils as Related to d. Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 219 334

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A pilot study of the deflection characteristics of a moving 12x22.5 tubeless tire shows the shape of the tire to be governed by the inflation pressure as well as the consistency or strength of the medium on which it operates. Results of the pilot study indicate that a comprehensive test program should be worthwhile.

KEYWORDS: Pneumatic tires; Tire deflection

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3 REPORT TITLE

DEFLECTION OF MOVING TIRES; TESTS WITH A 12.00-22.5 TUBELESS TIRE ON ASPHALTIC CONCRETE, SAND, AND SILT, 1959-1960

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5 AUTHOR(S) (Last name, first name, initial)

Green, A. J.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b. PROJECT NO 8S70-05-001, Trafficability and Mobility Research c Subproject -03, Mobility Fundamentals and Model Studies d	9a ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-516 Report No. 2 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 265 742

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

Five deflection gages, each consisting of a circular and a linear potentiometer coupled together, were installed in a 12-ply rating tire, mounted on a loaded 2-1/2-ton truck, to measure both translational and rotational movement of points on the inside surface of the tire. The truck was run on asphalt, sand, and silt surfaces. Vehicle speed, number of passes, wheel load, tire pressure, and temperature of the air within the tire were varied. Test results showed the shape of a moving tire to be determined primarily by wheel load, tire-inflation pressure, and type and condition of surface traversed. At constant inflation pressure, temperature variations within the range experienced during this test program did not affect tire-deflection patterns. The magnitude of the tire deflection decreased with repetitive traffic on the silt surface but not on the sand. Results also indicate that gages with two degrees of freedom are adequate for measuring tire deflection.

KEYWORDS: Flexible pavements; Pneumatic tires; Sands; Silts; Tire deflection; Tire test equipment

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1 ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a REPORT SECURITY CLASSIFICATION
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2b GROUP

3 REPORT TITLE
DEFLECTION OF MOVING TIRES; CENTER-LINE DEFLECTION STUDIES THROUGH JULY 1963

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 3 of a series

5 AUTHOR(S) (Last name, first name, initial)
Smith, M. E.
Freitag, D. R.

6 REPORT DATE
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10 AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES

12 SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13 ABSTRACT

Tire deflection data were studied from 30 tests performed in the single-wheel test facilities with pneumatic tires at various inflation pressures operating in Yuma desert sand and mortar sand of various strengths. Plots are presented of a path of points on the center line of the tires relative to a moving and a fixed frame of reference. Representative plots are included to show the effect of slip, soil strength, and inflation pressure on the path and to compare the paths of a point on the towed and powered tire.

KEYWORDS: Pneumatic tires; Sands; Tire deflection; Tire instrumentation

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3. REPORT TITLE

STRESSES UNDER MOVING VEHICLES; WHEELED VEHICLES (M135), LEAN AND FAT CLAY, 1957

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (Last name, first name, initial)

Thompson, A. B.
Smith, M. E.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-545 Report No. 2
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c. Subproject No. 8-70-05-400, Trafficability of Soils as Related to d. the Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 238 973

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Report No. 1 in this series is Miscellaneous Paper No. 4-230	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A study was conducted to determine the distribution of stresses imparted to a soil by a moving, pneumatic-tired vehicle and to compare the suitability of three different types of pressure-sensing devices for measuring these stresses. The effects on stresses of such variables as soil strength, tire-inflation pressure, vehicle speed, acceleration, deceleration, and towing of the vehicle were investigated with the cells installed at varying depths and offsets from the line of traffic. The large (6-in. diameter), earth pressure cell was found to be the most reliable measuring device of the three used in these tests. Inaccuracy of traffic alignment, variations in wheel load, variations in soil consistency, and cell movement were concluded to have been major causes of the discrepancies in stresses recorded by the cells. Recommendations for future tests, in which these detrimental conditions would be avoided, are included.

KEYWORDS: Clays; Pneumatic tires; Pressure cells (Soils); Stress distribution; Stresses under wheels; Wheeled vehicles; [M135 vehicles]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STRESSES UNDER MOVING VEHICLES; TRACKED VEHICLES (M29C, D4, and D7) ON FAT CLAY, 1956

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 3 of a series

5. AUTHOR(S) (Last name, first name, initial)

Green, J. E.
Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-545 Report No. 3
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c. Subproject No. 8-70-05-400, Trafficability of Soils as Related to d. the Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 241 537

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Results of a test program to measure stresses induced in fairly soft soils by moving tracked vehicles are presented. Three types of pressure-sensing devices were installed at several depths and offsets from an intended center line in prepared areas of fat clay, and the areas were trafficked by the M29C (weasel), and the D4 and D7 engineer tractors. Vehicle load and speed were varied. Movement of pressure cells and inconsistent readings of similarly placed cells discouraged a quantitative-type analysis; however, the test results indicated a qualitative analysis of pressure distribution beneath the tracks of the vehicles to be feasible. Some information was obtained on movement of soil beneath moving tracked vehicles. It is recommended that this type of test program be continued with better-controlled soil and traffic conditions and utilizing only one type of pressure-sensing device.

KEYWORDS: Clays; Pressure cells (Soils); Stress distribution; Stresses under tracks; Tracked vehicles; [D4, D7, M29C]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STRESSES UNDER MOVING VEHICLES; DISTRIBUTION OF STRESSES ON AN UNYIELDING SURFACE BENEATH STATIONARY AND TOWED PNEUMATIC TIRES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of a series

5. AUTHOR(S) (Last name, first name, initial)

Green, A. J.
McRae, J. L.
Murphy, N. R., Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This report presents results of tests to determine the magnitude and distribution of stresses beneath several types of pneumatic tires on an unyielding surface. Twenty-nine tests were performed, in which stresses were measured under six tires, differing in size, shape, and construction, at the points of contact with a firm surface. Five tires were tested at one load and forward speed, four of them at two inflation pressures or deflections and one at three inflation pressures. The other and largest tire (11.00-20, 12-PR) was tested at three loads and at three deflections for each load while both rolling forward and standing. The data showed a zone of high stresses near the edges of the tire contact area, the magnitude of the stresses increasing with wheel load, inflation pressure, and sidewall stiffness. Increase in inflation pressure significantly increased the magnitude of the stress in the center of the contact area. The stiffer tires distributed the load less evenly. It is recommended that: (a) The investigation of interface stress distributions on unyielding surfaces be suspended until tires having characteristics different from those tested become available. (b) A sufficient number of tests be conducted to develop a working knowledge of the tire-soil interface stresses induced by towed and powered pneumatic wheels in soft soils.

KEYWORDS: Pneumatic tires; Stress distribution; Stresses under wheels; Tire deflection

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3. REPORT TITLE
STRESSES UNDER MOVING VEHICLES; DISTRIBUTION OF STRESSES BENEATH A TOWED PNEUMATIC TIRE IN AIR-DRY SAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 5 of a series

5. AUTHOR(S) (Last name, first name, initial)
Green, A. J.
Murphy, N. R., Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-545 Report No. 5
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c. Task -03, Mobility Fundamentals and Model Studies	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 468 723
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10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT
Measurements of the magnitude and distribution of normal stresses at the tire-soil interface of an 11.00-20, 12-PR smooth pneumatic tire towed on air-dry mortar sand are presented. Deflection gages inside the tire measured its deflection, and pressure cells embedded in the surface of the tire measured the stresses at the tire-soil interface. Also, pressure cells installed at several depths within the soil mass beneath the center of the tire path measured stresses induced in the soil mass. Results indicate that the distribution of stresses at the tire-soil interface is related to the shape of the deflected tire and thereby to tire load, inflation pressure, and soil strength. Peak stress in the soil mass occurred well ahead of the axle of the test wheel, with the total load on the wheel having the greatest influence on its magnitude. The average stress waves for a tire-soil system such as used in this study can be expressed mathematically in terms of a Fourier series. Application of the Fourier series in stress wave analysis is discussed in Appendix A.

KEYWORDS: Pneumatic tires; Sands; Stress distribution; Stresses under wheels; Tire deflection

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3. REPORT TITLE
VALIDATION OF SOIL-STRENGTH CRITERIA FOR AIRCRAFT OPERATIONS ON UNPREPARED LANDING STRIPS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
C. D. Burns

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C.

13. ABSTRACT

The Waterways Experiment Station participated in aircraft operational tests conducted by the Air Force Operational Test Center at two test sites, Eglin AFB, Florida, and Pope AFB, North Carolina, which consisted of unprepared, sandy soil with sparse vegetation. Penetrometer readings obtained at the two sites before and during the tests were correlated with CBR and converted to approximate CBR values. Conclusions were that: (a) both the C-123B and C-130A can operate successfully on sand subgrades with surface ruts as deep as 4 to 6 in.; (b) the average soil strength for the 6- through 12-in. depth can be used for evaluating the load-carrying capacity of a sand subgrade; (c) increasing wheel loads at constant tire-inflation pressures up to 116,000 lb had little or no effect on depth of ruts; (d) increasing tire pressure for a constant or increasing wheel load resulted in more severe rutting and disturbance of the sand subgrade; (e) minimum subgrade strength requirements (based on average strength values for the 6- through 12-in. depth), as determined from tests with C-123B and C-130A aircraft, were in good agreement with streath requirements indicated by the previously developed CBR design curves; and (f) tentative strength criteria established by WES and ORDL for the operation of aircraft on unsurfaced soils are as good as can be established from data available at the present time.

KEYWORDS: Military bases; Soil strength; Unsurfaced airfields; [Eglin AFB, Fla.; Pope AFB, N. Carolina]

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3. REPORT TITLE
TESTS WITH RIGID WHEELS; TESTS IN FAT CLAY, 1958

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Smith, M. E.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001, Trafficability and Mobility Research c. Subproject -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-565 Report No. 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 266 510

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Results are presented of the first tests by the Army Mobility Research Center of a towed rigid wheel in a fairly soft soil. Speed was maintained constant. Load on the wheel was varied from test to test. Some variation in soil strength occurred along each test lane. Measurements were made of the following parameters: deviation in static load on the wheel, sinkage of wheel into the soil, motion resistance, contact pressure between the wheel face and the soil, strength (cone index) of the soil, and stresses induced within the soil mass. Various relations among the data are plotted, and expressed in mathematical terms. Measured stresses are compared with theoretical stresses.

KEYWORDS: Clays; Rigid wheels; Soil-wheel interaction; Stresses under wheels

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3. REPORT TITLE

PROJECT OTTER (OVERLAND TRAIN TERRAIN EVALUATION RESEARCH)
PRETEST REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Shamburger, John R.; Kolb, Charles R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

A test of the performance of the Overland Train in desert environment was conducted in 1962 at the Yuma Test Station, Arizona (YTA), using a system of terrain analysis and evaluation based on plan-profile, slope occurrence, slope, relief, soil type, soil consistency, rock type, and vegetation. The terrain factors of many world deserts, including the desert at Yuma, have been mapped. Fourteen test courses were tentatively selected at YTA subsequent to a comprehensive office study of terrain factor maps. Reasonably severe routes were chosen to test the mobility of the Overland Train. Terrain factor data and aerial imagery of the course were obtained. Terrain types were classified according to the WES mapping system along nine of the courses.

Illustrations, tables, maps

KEYWORDS: Desert regions; Military bases; Off-road mobility; Terrain analysis; Terrain factor maps; Overland Train; [Project OTTER; Yuma Test Station]

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3. REPORT TITLE

PROJECT OTTER (OVERLAND TRAIN TERRAIN EVALUATION RESEARCH); TEST REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report of series

5. AUTHOR(S) (Last name, first name, initial)

Shamburger, John H., and Duke, Leiland M.

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Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Research and Development Directorate, U. S. Army Materiel Command

13. ABSTRACT A program designed to objectively test and quantitatively evaluate the cross-country mobility of the Overland Train (a logistical cargo carrier) in a desert environment was conducted over selected courses at the U. S. Army Yuma Proving Ground, Arizona, during February and June 1963. A semiquantitative system for terrain classification, developed at the U. S. Army Engineer Waterways Experiment Station (WES) and used to classify several world deserts in the Northern Hemisphere, was utilized to describe the terrain along the selected courses at Yuma. Sixteen courses were tentatively selected at Yuma; however, tests were terminated after only two courses had been traversed. The following data were collected for each test course: fuel consumption; electrical energy required to operate the driving, traction, and steering systems; distance traveled; dust density; and acceleration at specific points on the train. These data were compared with "base values" obtained during train operation on a level, paved road. Effects of terrain on cross-country operation were: decrease in speed, increase in path length, and increase in fuel consumption. These effects were attributed to microgeometric features and the direction of travel across these features. Quantitative relations between speed in miles per hour and fuel consumption in gallons per mile were established. Terrain types, classified according to the WES mapping system, along the two test courses are compared to the terrain of deserts of North Africa, the Middle East, and South Central Asia.

KEYWORDS: Desert regions; Military bases; Off-road mobility; Terrain analogs; Terrain analysis; Overland Train; [Project OTTER; Yuma Test Station]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

OPERATION SWAMP FOX I, TERRAIN AND SOIL TRAFFICABILITY OBSERVATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)

Schreiner, B. G.
Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
See MP 4-556 for Swamp Fox II operation	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

In August-October 1961, the U. S. Army Transportation Corps conducted Operation Swamp Fox I, a 93-mile cross-country operation, in Panama. The Transportation Board formed the nucleus, command, and transportation agency for a combined technical services team of specialists. Waterways Experiment Station observers collected data on terrain, vegetation, and soils, and observed the effects of these factors on movement of twelve types of military, self-propelled, wheeled and tracked vehicles. They also tested instruments and techniques for determining trafficability of Panama soils. The data, collected under adverse conditions, are approximate and incomplete in many respects. Gullies, rivers, vegetation, wet surface-soil conditions, and particularly steep, frequent slopes were significant obstacles to vehicle movement. Difficult going necessitated dropping conventional wheeled vehicles early. The soils encountered were generally capable of supporting the vehicles used. The instruments and techniques used to determine soil trafficability appeared adequate. Further testing is recommended. An Appendix describes procedures for preparing vegetation structural diagrams.

KEYWORDS: Field tests; Military vehicles, Off-road mobility, Terrain analysis; Trafficability; Tropical regions; [Panama; Swamp Fox]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

ENVIRONMENTAL FACTORS AFFECTING GROUND MOBILITY IN THAILAND, PRELIMINARY SURVEY

4 DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report consisting of a main volume and eight appendices (A-H) in separate volumes.

5 AUTHOR(S) (Last name, first name, initial)

Rula, A. A.	Orvedal, A. C.	Ansted, G. W.
Grabau, W. E.	Harden, H. W.	Czako, T. F.

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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	Advanced Research Projects Agency Washington, D. C. 20315

13 ABSTRACT The study reported herein was a preliminary investigation made to provide guidance for a planned, longer range research program to develop and apply new and existing methods for measuring and predicting in quantitative and semiquantitative terms the effects of environmental factors on ground vehicles operating in Southeast Asia. The report is concerned specifically with the results of a field program conducted in Thailand. It presents a summary of the state of the art of measuring and predicting the effects of environmental factors on ground mobility, describes the environmental factors that affect ground mobility, presents the factor family concept and data adapted to ground-mobility purposes, and categorizes in tabular form environmental data by landscape types and subunits that occur in Thailand. Estimates of the probable effects of terrain factors on the performance of highly mobile vehicles are made for each landscape subunit. The report also presents conclusions and recommendations derived from an evaluation of the investigation. Eight appendices (A-H) were also published (in separate volumes) in conjunction with this report. Appendix A describes the results of a survey of unclassified existing data and literature. Appendices B, C, D, E, F, and G present methods of measurement and data tabulations and graphic presentations relative to the specific terrain factor with which each is concerned, i.e. soil classification, soil trafficability, vegetation, surface geometry, hydrologic geometry, and weather and climate, respectively. Appendix H presents an evaluation of the roads over which the preliminary survey test team traveled during the field data collection.

KEYWORDS: Environmental analysis; Environmental factors; Off-road mobility; Road tests (Vehicles); State-of-the-art studies; Terrain classification; Tropical regions; [Thailand]

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3. REPORT TITLE

STRENGTH-MOISTURE-DENSITY RELATIONS OF FINE-GRAINED SOILS IN VEHICLE MOBILITY RESEARCH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Smith, J. L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-639 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 450 623

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This study was undertaken to determine the relation of soil strength measurements obtained with the bevameter, the vane shear apparatus, the WES cone penetrometer, and the triaxial shear machine to the moisture content and density of two soils, a heavy clay and a lean clay, and to establish correlations between the various types of strength measurements. Directly measured soil strength values such as vane shear strength, cone index, pressure on a bearing plate (from the bevameter tests), and bevameter and triaxial shear strengths at a certain load or confining pressure reflect changes in soil moisture content and density with fair precision, whereas indirectly measured or derived values such as cohesion, friction angle, and the bevameter sinkage values are much less reliable. All soil values could be correlated with each other to some extent, except that friction angle apparently was not directly related to either of the penetration tests or to the vane shear test results.

KEYWORDS Fine grained soils; Laboratory tests; Soil density; Soil moisture; Soil property relations; Soil strength; Soil strength test instruments; Trafficability

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U. S. Army Engineer Waterways Experiment Station
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2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
TRAFFICABILITY TESTS WITH THE MARSH SCREW AMPHIBIAN ON COARSE-GRAINED AND FINE-GRAINED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)
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Rush, E. S.
Stinson, B. G.

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10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

The Marsh Screw Amphibian is of interest in the Army's mobility research program because of its unusual concept of locomotion which is based on the Archimedean screw. It moves by means of two counterrotating rotors which give forward and backward thrust to the vehicle. When both rotors are made to turn in the same direction, the vehicle will move laterally; however, there is no provision for steering when the vehicle is moving laterally. Trafficability tests with the Marsh Screw were performed to determine its performance on three soil types: sand, clay, and silt. Repetitive-pass tests and speed tests were conducted on clay and sand; towing tests on clay, silt, and sand; slope-climbing tests on sand; and obstacle tests on silt. For comparison, tests with an M29C weasel were conducted and performance curves from previous test programs were utilized. Appendix A presents a detailed description of the determination of mobility indexes and vehicle cone index for the Marsh Screw. Appendix B discusses the power train system.

KEYWORDS: Buoyant screw vehicles; Field tests; Mobility; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)
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2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH; STRENGTH-DENSITY RELATIONS OF AN AIR-DRY SAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Green, A. J.
Smith, J. L.
Murphy, N. R., Jr.

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

This study was undertaken to evaluate the ability of several soil strength measurements to detect and follow changes in sand density and to develop correlations between the various strength measurements. The instruments used included triaxial shear apparatus; direct shear apparatus; the bevameter, which included a ring shear device and circular plates of different diameters; the shear vane; and the WES cone penetrometer. It was found that the vane shear strength, the cone index, plate pressure, and the plate sinkage test values k_c and k_ϕ are related to soil density and consequently to each other. Equations relating the soil values were derived whenever practicable. The friction angles determined by the triaxial and direct shear tests are significantly larger than the bevameter shear friction angles.

KEYWORDS: Laboratory tests; Sands, Soil density; Soil property relations; Soil strength; Soil strength test instruments; Trafficability

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3. REPORT TITLE
MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH; AN EVALUATION OF THE RECTANGULAR HYPERBOLA FOR DESCRIBING THE LOAD-DEFORMATION RESPONSE OF SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (Last name, first name, initial)
Murphy, N. R., Jr.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT
A proposed technique for describing the soil stress-strain relations from triaxial tests and pressure-sinkage relations from plate-penetration tests was studied. Both sand and clay specimens, prepared in the laboratory, were used in the study. The proposed technique, which is based on the characteristics of a rectangular hyperbola, adequately portrayed the stress-strain relations examined. The pressure-sinkage relations usually required one hyperbola to describe the relation at shallow sinkages and another at greater sinkages. Certain of the hyperbolic parameters were found to be related to the physical characteristics of the soil test specimens. It is recommended that the study be extended to a wider range of soils and test conditions.

KEYWORDS: Laboratory tests; Pressure-sinkage relations; Stress-strain relations (Soils); Trafficability

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION

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3. REPORT TITLE

MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH, Report 3, EFFECTS OF VELOCITY, SIZE, AND SHAPE OF PROBES ON PENETRATION RESISTANCE OF FINE-GRAINED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

Three soils--a fat clay, a lean clay, and a loessial silt--were tested to determine the effects of penetration velocity, probe size, and probe shape on the penetration resistance of fine-grained soils. Velocities ranging from 0.0011 to 451 cm/sec were used to penetrate samples compacted at various water contents to provide soil consistencies from 103 to 1820 kN/m^2 standard penetration resistance. Two probe shapes were used--30-deg-apex-angle, right circular cones and flat, circular plates. Base areas of the cones ranged from 1.29 to 50.0 sq cm, and those of the plates from 9.93 to 39.70 sq cm. The relation of penetration resistance to velocity was not linear, so no constant "coefficient of viscosity" could be determined. The relation could best be described as that of a pseudoplastic material. The data revealed that the size dependence of penetration resistance was coupled with the velocity effect. Data at different speeds and sizes could be grouped on a single relation simply by employing the velocity/diameter ratio as the independent variable. From the experimental data, it was concluded that the soil response could be described as the sum of a viscous component and an inertial component. An apparent threshold velocity was found below which resistance was constant, but was attributed to the effect of water migration from the stressed zone at low penetration velocities. Data for the highest velocity tested in this study were higher than predicted, but the higher values could reasonably be accounted for by considering the effects of inertia. Further tests are needed at velocities much higher than those of this report to validate a behavorial model that includes the very-high-velocity condition.

KEYWORDS: Fine-grained soils; Laboratory tests; Penetrometers; Soil penetration tests; Soil strength relations; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH; Report 4, RELATIVE DENSITY AND CONE PENETRATION RESISTANCE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Klaus-Jurgen Melzer

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b. PROJECT NO 1T061102B52A, Research in Military Aspects of Off-Road Mobility, Task -01, Military Aspects of Off-Road Mobility	Technical Report No. 3-652, Report 4
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Relations between cone penetration resistance and relative density were developed by means of statistical analysis (correlation calculation) for three cohesionless soils: Yuma sand, mortar sand, and Bayou Pierre sand. These relations were evaluated from direct measurements of relative density and results of tests with the U. S. Army Engineer Waterways Experiment Station (WES) standard cone penetrometer. Most of the data for Yuma and mortar sands had already been obtained as part of the soil-tire performance tests previously conducted at the WES. However, several special laboratory tests in molds with both sands were conducted to control and extend the existing range of data. The results in Bayou Pierre sand were obtained from laboratory tests conducted especially for this study. The relations established between relative density and cone penetration resistance and its gradient, respectively, averaged over the 0- to 15-cm depth, depend on the grain size and compactibility of the soil. The cone penetration resistance increases with increasing soil mean grain diameter and decreasing compactibility. The critical depth of penetration affects the results within the considered depth range only in loose and very loose sands. A qualitative theoretical explanation of what occurs during the penetration of a cone into a cohesionless medium is given.

KEYWORDS: Cone penetrometers; Laboratory tests; Sands; Soil density; Soil penetration tests; Soil property relations; Soil strength; Trafficability

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH; Report 5, RESISTANCE OF FINE-GRAINED SOILS TO HIGH-SPEED PENETRATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Gerald W. Turnage

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Assistant Secretary of the Army (R&D)
Department of the Army
Washington, D. C.

13. ABSTRACT

Vertical penetration tests were conducted in three highly saturated, fine-grained soils--a fat clay, a lean clay, and a silt--with metal probes of six shapes--30-deg-apex-angle, right circular cones; flat circular plates; and flat rectangular plates with width-to-length ratios of 1:1, 1:2, 1:4, and 1:8. Probe sizes ranged from 0.323 to 59.1 sq cm; penetration velocities from 6 to 1221 cm/sec; and soil strengths (in terms of standard cone penetration resistance C_s) from 90 to 1315 kPa. Equations $C_{xs} = 1.0(V/\ell)_{xs}^{0.100}$ and $P_{xs} = 0.80(V/\ell)_{xs}^{0.100}$ adequately describe the viscous behavior of the two clays, and $C_{xs} = 1.0(V/\ell)_{xs}^{0.080}$ and $P_{xs} = 0.95(V/\ell)_{xs}^{0.100}$ serve this purpose for silt. (C_{xs} and P_{xs} are C_x/C_s and P_x/C_s, respectively, the ratio of soil penetration resistance per unit area of probe base for any given cone or plate, respectively, at any given velocity to that for the 3.23-sq-cm cone at 3.05 cm/sec. $(V/\ell)_{xs}$ is $(V_x/\ell_x)/(V_s/\ell_s)$, where V_x is penetration velocity of the probe that produced C_x or P_x, ℓ_x is square root of the base area of that probe, $V_s = 3.05$ cm/sec, and $\ell_s = \sqrt{3.23\ \text{cm}^2} = 1.80$ cm.) No noticeable inertial effects were produced in these tests. Plate penetration tests conducted horizontally at speeds to 27.35 m/sec in muddy clays at the Battelle Institute, Frankfurt, Germany, produced soil lift forces strongly influenced by inertial effects. These effects are described by an improved dimensionless lift coefficient C_L versus plate-soil numeric (π_s) logarithmic relation that effectively accounts for the influence of penetration velocity and plate inclination angle.

KEYWORDS: Fine-grained soils; Penetration resistance (Soils); Plate bearing tests; Soil penetration tests

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	2b. GROUP

3. REPORT TITLE

MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH; Report 6, RESISTANCE OF COARSE-GRAINED SOILS TO HIGH-SPEED PENETRATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Assistant Secretary of the Army (R&D) Department of the Army Washington, D. C.

13. ABSTRACT

For a given probe (cone or flat plate) tested vertically in air-dry sand of a given strength level, the curve of probe base pressure (sand penetration resistance force per unit probe base area, F_z/A_x) versus probe base depth departs from near-linearity as velocity V_z increases. For these conditions, values of probe base pressure at shallow depth increase with increasing velocity, but this pressure approaches a common value at substantial depth (say, 15 cm) for velocity values in the 3- to 600-cm/sec range.

For a velocity near 3 cm/sec, the slope, or gradient, of the probe base pressure versus depth curve (termed penetration resistance gradient G_x) can be expressed for any of a broad range of probe sizes and shapes by $G_x = \left\{\left(G - 1\right) \times \left[0.20 + \left(0.80 \frac{\ell_s}{\ell_x}\right)\right] \ 1\right\}$ where G is G_x measured under standard conditions (i.e. by a 3.23-sq-cm, 30-deg-apex-angle cone at 3.05 cm/sec), ℓ_s is A for the standard cone, and ℓ_x is the Ax for the probe of interest. Expressions were also developed to describe F_z at shallow probe depths (zero base depth for the cones, 2.5-cm depth for the plates) as a function of sand strength and probe size, shape, and velocity for a wide range of values of each of these variables. Finally, a technique is presented for estimating the F_z versus depth curve in the 0- to 15-cm depth range for cones, or the 2.5- to 15-cm depth range for plates, for V_z values less than about 100 cm/sec and any of a wide range of sand strengths and probe sizes and shapes. A second phase of this study determined expressions that describe the marked increase in sand G values caused by increases in sand unit dry weight γ_d and/or moisture content. In the third phase of this study, dimensional analysis was used to develop a description of the horizontal force acting on a given cone base as the cone moves horizontally beneath the sand F_x) as a function of probe size and velocity; depth of the cone tip relative to the undisturbed sand surface; and air-dry sand G and γ_d. A short review of major findings from two studies of horizontal cone penetration tests showed that these findings agree with and complement results of the WES study. A brief summary of another study presents related expressions that describe the horizontal and vertical components of force on plane blades operating horizontally near the sand surface.

KEYWORDS: Penetration resistance (Soils); Plate bearing tests; Sands; Soil penetration tests

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4. TITLE (and Subtitle) MEASURING SOIL PROPERTIES IN VEHICLE MOBILITY RESEARCH; Report 7, BEHAVIOR OF FINE-GRAINED SOILS UNDER HIGH-SPEED TIRE LOADS		5. TYPE OF REPORT & PERIOD COVERED Report 7 of a series 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Gerald W. Turnage		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

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Fine-grained soils
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Performance predictions
Pneumatic tires
Soil-wheel interaction
Tire performance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study examined the effects of wheel speed on the performance in fine-grained soils of single pneumatic tires, full-size wheeled vehicles, and a prototype aircraft under several tire operational modes. Results from powered-wheel single-tire tests conducted at WES showed that the dimensionless clay-tire numeric $N_{cl} = (C_s bd/W) \times (\delta/h)^{1/2} \times 1/[1 + (b/2d)]$, where C_s = standard cone index, b = tire section width, d = tire diameter, W = wheel load, and δ/h = tire deflection ratio, can be used to describe tire performance (Continued)

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20. ABSTRACT (Continued).

at speeds to at least 18 ft/sec if the value of C_s in N_{c1} is adjusted to reflect viscouslike soil strength behavior caused by tire-soil interaction. Results from WES speed tests of five prototype wheeled vehicles in the field indicated that the same velocity-adjusted numeric as above (except that rating cone index RCI replaces cone index C_s) is closely related to the soil motion resistance coefficient R_s/W_v. Data from tests conducted for the U. S. Air Force showed that for one particular combination of aircraft, running gear, and wing-flap setting, a clay-tire numeric, $N_{c0} = (C_s bd/W) \times (\ell/h)^{1/2}$, is closely associated with the percent increase in takeoff distance required on unsurfaced clay runways as compared to that on a paved runway. From another study conducted for the Air Force, data revealed that a relation between the dimensionless drag coefficient and the Reynolds number (modified from fluid mechanics to fit the clay-tire situation) can be used to describe the combined influence of viscouslike and inertial changes in soil strength on the drag of a free-rolling tire at speeds to about 150 ft/sec. For the braked-wheel operational mode, a simple method of predicting drag ratio (D/W) was developed on the basis of a reasonably stable, linear relation that exists between D/W and the rut depth coefficient (r/d) for wheel speeds to about 150 ft/sec.

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3. REPORT TITLE

TRAFFICABILITY TESTS ON CONFINED ORGANIC TERRAIN (MUSKEG); SUMMER 1961 TESTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 1 in a series.

5. AUTHOR(S) (Last name, first name, initial)
Radforth, N. W.
Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1964	112	14

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-656 Report 1
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A pilot program of a limited number of trafficability tests with four vehicles (a 20-in.-track Weasel, a 10-in.-track Weasel, a Water Buffalo, and a Dinah) was conducted in eight confined muskeg areas in Ontario, Canada. Frequent failures of mechanical components of the vehicles because of muskeg clogging the track systems hampered the test program. Results showed the cone penetrometer and shear vane to have promise as tools for measuring trafficability of muskeg. The standard Weasel (with 20-in-wide tracks) could negotiate the relatively dense muskeg but was immobilized on the floating-mat type (mechanical failures excluded). The Weasel equipped with special, 10-in.-wide tracks had occasional difficulty even in the more consolidated bogs. Towing abilities of the Weasels were nearly 100% of their weights. In addition to the self-propelled and towing tests with the Weasels, four self-propelled tests were conducted with a Water Buffalo, and two with a Dinah. On a qualitative basis, ranges of trafficability potential were disclosed in the tests, and these were tentatively related to characterisitc differences in peat, cover, and terrain-water relations. Additional tests need to be conducted in the same areas with a range of vehicle types before acceptable correlations between vehicle performance and muskeg type and condition can be expressed.

KEYWORDS: Field tests; Military vehicles; Mobility; Muskeg; Soil strength test instruments; Tracked vehicles; Trafficability; [Dinah; Parry Sound, Ontario, Canada; Water Buffalo; Weasel]

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3. REPORT TITLE

TRAFFICABILITY TESTS ON CONFINED ORGANIC TERRAIN(MUSKEG); SUMMER 1962 TESTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series; 2 volumes

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.
Schreiner, B. G.
Radforth, N. W.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A program of trafficability tests with 10 tracked vehicles was conducted in nine confined muskeg areas in Ontario, Canada. One hundred and forty-one single self-propelled tests, 8 towing tests, 5 towed-vehicle tests, and 12 torque-requirement tests were conducted. Results showed that vehicle performance on a self-propelled (go-no go) basis can be correlated reasonably well with cone index of muskeg. Vehicle weight appears to be the most significant vehicle factor affecting performance. Cone index values in the various muskeg surface cover formulas varied widely, being influenced principally by the quantity of water present. The data obtained did not reveal even a general relation between muskeg surface cover formula and cone index. Anomalies occurred in relations of vehicle performance to cone index of muskeg, suggesting that although cone index appears to be a prime indicator of muskeg trafficability, it will be necessary to examine other physical properties of the medium as well.

KEYWORDS: Field tests; Military vehicles; Mobility; Muskeg; Tracked vehicles; Trafficability; [Parry Sound, Ontario, Canada]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP

3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TIRE LOADS; TEST FACILITIES AND TECHNIQUES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (Last name, first name, initial)

McRae, J. L.
Powell, C. J.
Wismer, R. D.

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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-666 Report No. 1
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This report presents introductory and background information on research being conducted on performance of soils under tire loads, and describes in detail the test facilities and techniques used by the Army Mobility Research Branch, Mobility and Environmental Division, U. S. Army Engineer Waterways Experiment Station. It also includes a complete list of definitions of mobility terms with particular reference to those concerning pneumatic tires.

KEYWORDS: Glossaries; Mobility; Pneumatic tires; Soil-wheel interaction; Test facilities; Test techniques; Mobility research laboratories [Waterways Exp Sta.]

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3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TIRE LOADS; ANALYSIS OF TESTS IN YUMA SAND THROUGH AUGUST 1962

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (Last name, first name, initial)

Powell, C. J.
Green, A. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A total of 709 tests performed with single pneumatic tires in Yuma desert sand placed in movable sand bins in the laboratory are analyzed. Basic plots are presented to show the correlations obtained between individual variables. Representative cross plots are included to show the effects of tire width and diameter and to illustrate the relative effectiveness of the various tires tested. Initial steps in the development of a numeric that will define a single relation between dependent and independent variables for all tires and test conditions are reported.

KEYWORDS: Laboratory tests; Mobility numbers; Performance predictions; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance; Trafficability

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3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TIRE LOADS: TESTS IN CLAY THROUGH NOVEMBER 1962

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Wismer, Robert D.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This report analyzes the results of 184 multiple-pass tests with a single, smooth, pneumatic tire (9.00-14, 2-PR) in a fat clay at a high degree of saturation. These tests were performed using a wide range of tire loads, tire deflections, and soil strengths. Some of the tests were conducted to study the influence of speed on performance. Basic plots of the data (one dependent versus one independent variable with all other independent variables held constant) show the relative effect of each independent test variable on tire performance. Scatter of the pull and torque data points was found to be quite large for the early tests. An examination of the data showed that a difference in soil strength between the soil surface and the remainder of the soil mass was the probable cause of the scatter. Improvement in soil processing techniques subsequently produced more uniform soil conditions and virtually eliminated this scatter in the later tests. A simple static analysis was found adequate to represent the forces and moments on a towed or powered pneumatic tire operating at small sinkages in a soft clay.

KEYWORDS: Clays; Laboratory tests; Performance predictions; Pneumatic tires; Soil-wheel interaction; Tire performance; Trafficability

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PERFORMANCE OF SOILS UNDER TIRE LOADS; ANALYSIS OF TESTS IN SAND FROM SEPTEMBER 1962 THROUGH NOVEMBER 1963

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Turnage, Gerald W.
Green, Andrew J., Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task-03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-666 Report 4 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 632 245

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The effects of tire deflection, tread, carcass stiffness, construction speed, and slip on tire performance in a dry sand are examined. Laboratory test results indicate that for best performance in a dry sand a tire should be highly deflected, smooth, and of diagonal-ply construction. Variations in carcass stiffness have negligible effects on tire performance when deflections and loads are equal. It was concluded that the performance of pneumatic tires in sand is affected by speed; however, the extent of this influence is not wholly determined. Logical, orderly relations are shown between slip and several independent and dependent variables--wheel load, soil strength, pull, and sinkage--both at the towed and maximum pull points. A direct relation is shown between the pull developed by a 4x4 vehicle and that developed by a single wheel in multiple passes. Good agreement was attained in this relation for both Yuma (desert) and mortar sand. Significant differences in tire performance registered in Yuma and mortar sands at corresponding strength levels prompted a study of the physical characteristics of the two soils. This study revealed notable differences in the strength characteristics that explain a portion of the differences in tire performance in the two sands.

KEYWORDS: Laboratory tests; Performance predictions; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance; Trafficability

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3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TIRE LOADS: Report 5, DEVELOPMENT AND EVALUATION OF MOBILITY NUMBERS FOR COARSE-GRAINED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 5 of a series

5. AUTHOR(S) (Last name, first name, initial)

Andrew J. Green

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

This study examined the effects of tire deflection, tire geometry, wheel load, and soil strength on the performance of coarse-grained soils subjected to moving tire loads. Mathematical expressions were developed that combine the independent tire-soil and system parameters and relate them to the performance coefficients. A combination of independent parameters, $\frac{C(bd)^{3/2}}{W} \times \frac{\delta}{h}$, was developed from single-wheel laboratory tests. This expression, referred to as the sand mobility number, is shown to account for the combined effects of soil strength (G), tire section width and diameter (b and d, respectively), wheel load (W), and tire deflection (δ/h) on wheel performance as measured by the performance coefficients. A multiple-pass analysis was conducted to illustrate that performance on the second and third passes also could be related to the sand mobility number, although the relation was not the same as that for the first pass. It was shown in a similar fashion that the performance of vehicles on coarse-grained soils could be predicted using a relation based on the sand mobility number.

KEYWORDS: Dimensional analysis; Mobility numbers; Performance predictions; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance; Trafficability

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss. 39180

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
PERFORMANCE OF SOILS UNDER TIRE LOADS; EFFECTS OF TEST TECHNIQUES ON WHEEL PERFORMANCE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 6 of a series

5. AUTHOR(S) (First name, middle initial, last name)
Newell R. Murphy, Jr.

6. REPORT DATE
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c. Task -03, Mobility Fundamentals and Model Studies

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

A study was made of the effects of various testing techniques on the performance of pneumatic tires operating in an air-dried desert sand and a nearly saturated fat clay. Tests employing both controlled-slip and controlled-pull techniques were conducted with single-wheel dynamometer carriages. The results are presented in the form of graphs with emphasis placed upon the pull-slip and torque-slip relations. For the conditions tested, wheel performance was found to be independent of testing techniques, with one exception; consistent differences were noted between the results of programmed-increasing- and programmed-decreasing-slip tests. However, this disagreement occurred only for a narrow range of slip (approximately -10 to +10%). Careful and complete analysis of a dynamic test system must be made to determine the forces that actually represent the wheel performance. A brief analysis of the horizontal forces acting on the test dynamometers is given to emphasize this point, particularly with regard to differences between pull-slip and drawbar pull-slip relations. It is shown that because of the inability always to attain a stable condition in controlled-pull tests, controlled-slip tests are better for defining pull-slip relations.

KEYWORDS: Clays; Laboratory tests; Performance predictions; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
PERFORMANCE OF SOILS UNDER TIRE LOADS; Report 7, EXTENSION OF MOBILITY PREDICTION PROCEDURES TO RECTANGULAR-CROSS-SECTION TIRES IN COARSE-GRAINED SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Thomas R. Patin

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046 c. Task 03 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-666, Report 7 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 741 770

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Directorate of Research, Development and Engineering, U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT
The study reported herein was conducted to determine whether the sand mobility number that had been developed for circular-cross-section tires operating in a particular coarse-grained, air-dry soil could be used to predict the performance of rectangular-cross-section tires in the same or a second coarse-grained, air-dry soil. Five rectangular-section tires were tested in each of two coarse-grained soils, a desert sand from Yuma, Arizona, and a mortar-type sand from a river deposit near Vicksburg, Mississippi. The data collected in these tests were compared with relations previously developed from tests with circular-section tires in air-dry Yuma sand. Analysis of test results showed that the existing sand mobility number can be used to predict the performance of rectangular-section tires in both test sands.

KEYWORDS: Laboratory tests; Mobility numbers; Performance predictions; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TIRE LOADS; Report 8, APPLICATION OF TEST RESULTS TO TIRE SELECTION FOR OFF-ROAD VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 8 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-666, Report 8
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Research, Development and Engineering Directorate, U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Data from a very large block of previously collected data from laboratory single-wheel tests and from selected field tests were examined to: (a) determine whether the dimensionless prediction terms for sand $\frac{G(bd)^{3/2}}{W} \cdot \frac{\delta}{h}$ and for clay $\frac{Cbd}{W} \cdot \left(\frac{\delta}{h}\right)^{1/2}$ could be improved, and (b) extrapolate laboratory relations to field relations for full-size vehicles. (In these terms C and G are penetration resistance and penetration resistance gradient, respectively, for clay and sand, b is tire width; d is tire diameter. h is section height; δ is tire deflection; and W is wheel load.) The term for sand and an improved term for clay $\frac{Cbd}{W} \cdot \left(\frac{\delta}{h}\right)^{1/2} \cdot \frac{1}{1 + (b/2d)}$ were designated the basic prediction terms. These basic terms predict dimensionless tire performance coefficients pull/load (P/W), sinkage/diameter (z/d), torque/load · active radius (M/Wr_a), all at 20 percent slip (near maximum pull), and towed force/load (P_T/W) quite well for many sizes and shapes of pneumatic tires in the laboratory sands and clay. Other alternative terms examined for both sand and clay predict the performance of tires or wheels of very small δ/h values more accurately than the basic terms, but predict performance of conventional pneumatic tires less accurately. When dimensionless terms $\left(150V_w/V_{sh}\right)^{1/2}$ and $\left[0.1(V_w/b)/(V_s/d_s)\right]^{0.092}$ are attached to the basic prediction terms for sand and clay, respectively, the P/W versus prediction term relations are effectively collapsed to single lines for wheel translational velocities (V_w) in the <1 to 18 ft/sec range. (V_{sh} is shear wave velocity, V_s is standard penetration velocity, and d_s is diameter of a standard cone.) The basic prediction terms can serve as the base for predicting wheeled vehicle performance in the field if RCI (rating cone index) is substituted for C in the term for clay. Equations that describe the pertinent relations are examined in detail, and examples illustrate several of their many possible applications.

KEYWORDS: Dimensional analysis; Mobility numbers; Performance predictions; Pneumatic tires; Soil-wheel interaction; Tire performance

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U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	Unclassified
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3. REPORT TITLE

WHEELS ON SOFT SOILS; AN ANALYSIS OF EXISTING DATA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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Secretary of the Army Research and Study Fellowship for September 1961-August 1962	Technical Report No. 3-670
b. PROJECT NO.	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	AD 457 877

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Department of the Army

13. ABSTRACT

Wheel performance data from almost 3000 tests are tabulated and analyzed. Principally these tests were conducted on two general soil groups that are termed frictional and nonfrictional. Rigid-tired and pneumatic-tired wheels are represented. The force required to tow transport wheels and the maximum pull developed by traction wheels are considered to be measures of performance. The data are analyzed to show the effects of load, tire geometry, and soil strength on wheel performance. Among the tire geometry variables examined are diameter, width, deflection, carcass construction, and tread pattern. It is shown that wheel performance varied systematically with the test variables. Much of this variation is described closely by mathematical expressions that are derived. In both soil groups load and soil strength always have an important influence on performance. In frictional soils tire diameter, width, and deflection are very influential while tread pattern and carcass construction are not. In nonfrictional soils tire diameter, width, and deflection have some influence and tread pattern can be very important under particular circumstances. Very little benefit is derived from dual tires and for traction on frictional soils duals are relatively inefficient.

KEYWORDS: Dimensional analysis; Mobility numbers; Performance predictions; Pneumatic tires; Rigid wheels; Soil-wheel interaction; Tire performance

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP
3 REPORT TITLE MOBILITY ENVIRONMENTAL RESEARCH STUDY; A LITERATURE SURVEY OF ENVIRONMENTAL FACTORS IN THAILAND	
4 DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 1 of series	
5. AUTHOR(S) (Last name, first name, initial) Broughton, Jerald D. Shamburger, John H. Del Mar, David B.	
6 REPORT DATE June 1965	7a TOTAL NO OF PAGES 336 7b. NO. OF REFS 1613
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c ARPA Order No. 400 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-681, Report 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 620 030
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11 SUPPLEMENTARY NOTES Service Agent: Army Materiel Command Washington, D. C.	12. SPONSORING MILITARY ACTIVITY Office, Secretary of Defense Advanced Research Projects Agency Washington, D. C.

13 ABSTRACT

The survey reported herein was a search for maps, written text or description and aerial photographs that would be useful in quantitatively describing the physical attributes of the environment found in Thailand that affect ground mobility. These physical attributes include surface geometry, soils, vegetation, hydrologic geometry, and climate. Sections corresponding to the physical attributes and a general section were established for filing and cross-filing references according to their data content. Each section was further subdivided into two subsections, text and map references.

A list of 1613 unclassified references was compiled, and the contents of each reference were evaluated according to the following categories: (a) quantitative data, (b) qualitative data, (c) useful data absent, (d) gazetteers, bibliographies, etc., and (e) not reviewed. Of these references, 1012 were reviewed and annotated, 484 were cross-filed, and 117 were not reviewed. Geographic index maps were prepared to show specific areas of Thailand described in the annotated references when these areas were less than the entire country. Each bibliographic entry is identified by a series of symbols indicating (a) section and reference number, (b) subsection (text, maps, or both), (c) evaluation category, and (d) if and where cross-filed.

KEYWORDS: Bibliographies; Environmental analysis; Environmental factors; Mobility; State-of-the-art studies; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified; 2b GROUP

3. REPORT TITLE
A DIMENSIONAL ANALYSIS OF THE PERFORMANCE OF PNEUMATIC TIRES ON SOFT SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1965	141	22

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c. Task -03, Mobility Fundamentals and Model Studies	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Was also submitted as dissertation for degree of Doctor of Philosophy in Engineering to Auburn University, Auburn, Ala.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT Treadless pneumatic tires were tested in specially prepared wet clay and dry sand. Horizontal and vertical forces, torque, slip, and sinkage were measured. The test variables included tire width and diameter, tire deflection, and the load on the tire. The soil strength was varied over the full practicable range. A dimensional analysis of the tire-soil systems tested yielded four principal independent Pi terms: the shape number $\frac{b}{d}$, the deflection number $\frac{\delta}{h}$, the clay loading number $\frac{Cd^2}{W}$, and the sand loading number $\frac{Gd^3}{W}$. Four dependent Pi terms--the pull number $\frac{P}{W}$, the sinkage number $\frac{z}{d}$, the torque number $\frac{Q}{dW}$, and the towed force number $\frac{P_T}{W}$--were used as measures of tire performance. The experimental results showed, both for the clay and the sand, that the consistency of the soil could be evaluated, and that true scaled systems could be achieved. A single term was developed for each of the soils that combined all of the independent parameters and this term was shown to be related to the dependent parameters. Curves delineating the following relations were developed and verified:

$$\frac{P}{W}, \frac{z}{d}, \frac{Q}{dW}, \frac{P_T}{W} = f\left[\frac{Cbd}{W}\left(\frac{\delta}{h}\right)^{1/2}\right] \text{ for clay; } \frac{P}{W}, \frac{z}{d}, \frac{Q}{dW}, \frac{P_T}{W} = f\left[\frac{G(bd)^{3/2}}{W}\frac{\delta}{h}\right] \text{ for sand}$$

KEYWORDS: Dimensional analysis; Laboratory tests; Mobility numbers; Performance predictions; Pneumatic tires; Soil-wheel interaction; Tire performance; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; LABORATORY INVESTIGATIONS IN THE 0.76- TO 5.00-MICRON SPECTRAL REGION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 1 of 3 series

5. AUTHOR(S) (Last name, first name, initial)
Davis, B. R.
Lipscomb, E. B.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -04, Mobility Terrain Analysis and Symbology d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-693 Report No. 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 472 873

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT
This report presents the results of tests conducted to determine the capabilities of active electromagnetic sensors operating in the 0.76- to 5.00-micron spectral region to measure terrain characteristics affecting trafficability of soils. Controlled tests were conducted under laboratory conditions in an attempt to correlate the effects of soil composition, moisture content, and density with the quantity of infrared energy reflected from a soil sample. Results of the tests indicate that the composition and moisture content of homogeneous soil specimens can be characterized by active infrared sensors under controlled laboratory conditions. However, since infrared energy is reflected by infinitesimally thin surfaces of materials, information concerning density and subsurface parameters cannot be discerned. Techniques for prediction of soil parameters through the use of multiwavelength analysis are discussed.

KEYWORDS: Infrared rays; Laboratory tests; Remote sensing; Soils; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; RADAR RESPONSES TO LABORATORY PREPARED SOIL SAMPLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 2 of a series

5. AUTHOR(S) (Last name, first name, initial)
Lundien, Jerry R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1966	99	12

8a. CONTRACT OR GRANT NO. NASA Defense Purchase Request No. R-25-04-001	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-693 Report 2
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10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Service Agency: U. S. Army Materiel Command Washington, D. C.	National Aeronautics and Space Administration, Washington, D. C.

13. ABSTRACT Laboratory tests were conducted with radar sensors to detect the presence of and measure the depth to subsurface interfaces when the surface was bare, and to determine the influence of vegetation at various stages of growth on radar responses. A secondary purpose was to continue earlier studies to relate radar returns and the electrical constants that they provided to moisture content and density of samples. Large laboratory samples were prepared at various moisture contents and densities and with various depths to a subsurface metal plate. Standard pulsed radar sensors operating with frequencies of 297, 5870, 9375, and 34,543 megacycles/sec and directed at various angles of incidence to the surface were employed. The results of this laboratory study indicate that the standard pulsed radar sensors can provide information that will permit an estimate of the moisture content of deep, homogeneous soil samples and the detection of surface vegetation of various heights. Radar signatures of vegetation-covered soil were more significantly altered at Ka-, X-, and C-band frequencies than at P-band frequencies. However, standard pulsed radar sensors used monochromatically cannot provide information for predicting depth to subsurface interfaces or for directly indicating the presence of a subsurface interface. The systematic manner in which soil depths were varied in this study permitted an analytical solution to the problem of measuring depths of layers and led to the conclusion that properly designed radar systems could measure depths to subsurface interfaces. Three such systems are proposed.

KEYWORDS: Laboratory tests; Radar; Remote sensing; Soils; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss. 39180

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS: Report 3, LABORATORY INVESTIGATIONS IN THE 0- TO 2.82-MEV GAMMA-RAY SPECTRAL REGION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Jerry R. Lundien

6. REPORT DATE
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7a. TOTAL NO. OF PAGES
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8a. CONTRACT OR GRANT NO.

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d.Research, Task -04, Mobility Terrain Analysis and Symbology

9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

Gamma-ray spectra over the energy range 0 to 2.82 mev were obtained from samples of sand, silt, and clay. All tests were conducted in the laboratory in a specially designed low-background enclosure. Data were analyzed by considering both photopeak energy level and radioactive source content in relation to soil parameters.

The results indicate that the thorium, uranium, and potassium photopeak counts are proportional to moisture content expressed as a percentage of dry soil weight. When expressed as ratios to one another, the photopeaks lose nearly all moisture content information but appear to be related to each of the three selected specific soil types.

Appendixes A and B present a listing of the FORTRAN computer program and a discussion of the data reduction techniques that it uses in the analysis of gamma-ray spectral data.

KEYWORDS: Gamma rays; Laboratory tests; Remote sensing; Soils; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)

U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION

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2b. GROUP

3. REPORT TITLE

TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS: REPORT 4; LABORATORY INVESTIGATIONS OF THE INFRARED EMISSIVITY OF SOILS BELOW A WAVELENGTH OF 7.7 MICRONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Lavecchia, Nicholas J., Jr.
Williamson, Albert N., Jr.
Nikodem, Hans J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO 1-V-0-14501-B-52A, Research in Earth Sciences, Task -01, Terrain Analysis

c. 1-V-0-21701-A-046, Trafficability and Mobility Research, Task -04, Mobility

d. Terrain Analysis and Symbology

9a. ORIGINATOR'S REPORT NUMBER(S)

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Report 4

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

This report presents the results of tests using a passive infrared scanning system responsive to radiation below approximately 7.7 microns to determine if a correlation could be found between the infrared emissivity of soils and their trafficability parameters. It was established that a relation between the passive emission of soils and soil surface moisture content can be measured, but contributing factors other than soil emissivity were encountered. These factors were soil surface temperature and incident radiation on the soil surface. These factors so influenced the magnitude of the net detected energy that this measurement is meaningless, in terms of soil emissivity, unless the contribution of the other factors is known. Progressive modifications in measuring techniques were made in an attempt to isolate these components. The data indicate that the information that can be obtained from a passive infrared sensor using the technique derived herein is not sufficient to determine emissivity values of terrain with sufficient accuracy for practical application.

KEYWORDS: Infrared rays; Laboratory tests; Remote sensing; Soils; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; Report 5, LABORATORY MEASUREMENT OF ELECTROMAGNETIC PROPAGATION CONSTANTS IN THE 1.0- to 1.5-GHz MICROWAVE SPECTRAL REGION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Jerry R. Lundien

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

This investigation was made to (a) measure the basic electrical properties of various test samples at frequencies ranging from 1.074 to 1.499 GHz with an L-band interferometer and (b) to relate these basic electrical properties to the physical properties of the test samples. Twelve soils, described in Appendix A, were used in the test program. Laboratory tests on soil samples at various moisture contents and densities indicate a strong, nearly linear relation between the volumetric water content and relative dielectric constant. This relation is not greatly affected by changes in soil density, soil type, or small changes in frequency. Similar relations also exist between loss tangent and electrical conductivity and volumetric water content as modified by frequency, and may be useful for soil type identification. Tests were also run on samples of water and a sample of concrete. Results from the water samples show a decrease in the relative dielectric constant, loss tangent, and electrical conductivity with increasing temperature. The decrease in relative dielectric constant appears to be uniform with temperature from 0 to 65 C and is slightly less than 1/2 percent/C. This ratio may prove useful in estimating the effects of temperature change on the electrical properties of a soil-water mixture. Dielectric constant measurements are shown to be a sensitive measure of water loss in a concrete sample. In addition to the L-band interferometer, two other dielectric constant measurement devices are described in Appendixes B and C and the results of tests with these devices are presented. These are (a) a capacitor measuring system operating between 1 and 75 MHz for soil and water samples and (b) an open wire line (OWL) probe operating between 1 and 2 GHz for soil and concrete samples. **KEYWORDS: Concrete samples; Laboratory tests; Microwaves; Remote sensing; Soils; Trafficability**

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE

CHARACTERISTICS OF U.S. RICE FIELDS AND THEIR EFFECTS ON GROUND MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (Last name, first name, initial)
Kennedy, J. G.
Rush, E. S.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO

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9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES
Service Agent:
U. S. Army Materiel Command
Washington, D. C. 20315

12. SPONSORING MILITARY ACTIVITY
Advanced Research Projects Agency
Washington, D. C. 20315

13. ABSTRACT

The primary objective of this study was to obtain information on the environmental characteristics of rice fields in the United States and the effect of these characteristics on ground mobility for comparison with similar characteristics of rice fields in Southeast Asia. Twenty-two study sites were located in rice fields in a variety of soil types and under various cultural practices in Arkansas and Louisiana. Fifteen of these sites were selected to be visited for data collection several times during a one-year period. Data collected were soil moisture, soil strength, vegetation characteristics, surface geometry, hydrologic geometry, cultural practices, and weather. General conclusions were: (a) for most sites a good correlation exists between soil strength and soil-moisture content; (b) estimates of soil strength can be made by employing the WES soil moisture-strength prediction method; (c) surface geometry features of U. S. rice fields would not be a significant deterrent to ground vehicles; (d) the soil strength in the fields tested is adequate to support at least one pass of most military vehicles; and (e) most hydrologic geometry features in U. S. and Southeast Asian rice fields are insurmountable for present standard military vehicles.

KEYWORDS: Environmental analysis; Environmental factors; Rice fields; Temperate regions; Terrain analogs; Trafficability; Tropical regions; [Thailand, Miss River floodplain]

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
A STUDY OF THE EFFECTS OF WET SURFACE SOIL CONDITIONS ON THE PERFORMANCE OF A SINGLE PNEUMATIC-TIRED WHEEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Smith, J. L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c. ARPA order No. 400

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9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES
Service Agent:
U. S. Army Materiel Command
Washington, D. C. 20315

12. SPONSORING MILITARY ACTIVITY
Advanced Research Projects Agency
Washington, D. C. 20301

13. ABSTRACT

Tests were conducted with a powered wheel to determine the effects of wet surface soil conditions on the performance of pneumatic tires. Surface soil conditions were of three types: (a) unflooded, (b) flooded and undrained, and (c) flooded and drained. Tests were conducted on fat clay and silt. All test tires were 6.00-16, 4-PR. Four tire surfaces, or tread patterns, were tested: a smooth tire (i.e. no tread), a directional tread, a nondirectional tread, and a smooth tire with traction aid.

It was found that for a given wheel load the loss of pull (used to express performance) due to flooding was essentially constant for each tread pattern. The treaded tires and the smooth tire with traction aid performed better than the smooth tire in flooded soil, but there was no significant difference between the tread patterns other than smooth. In the unflooded soil, the tread pattern made a considerable difference in performance. Peak performance usually was attained at an optimum load, regardless of tread pattern or soil condition. Pull remained unchanged through five passes in the unflooded soil, increased with each pass in the flooded-and-drained soil, and decreased with traffic in the flooded-and-undrained soil. Magnitude of pull was dependent to some extent on duration of flooding. Lowest pulls due to slipperiness were attained when the flooding period was very brief and the soil strength high.

KEYWORDS: Fine-grained soils; Flooded soils; Laboratory tests; Pneumatic tires; Soil-wheel interaction; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SUMMARY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume I of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)

John H. Shamburger
Warren E. Grabau

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Order No. 400 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-726 Volume I 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 835 392

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Service Agency; U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

Terrain factors that significatly affect the locomotion of ground-contact vehicles are encompassed in four factor families—surface composition, surface geometry, vegetation, and hydrologic geometry. Since a condition of this study was to establish the effects of terrain on vehicle locomotion in Southeast Asia, six areas in Thailand were selected for detailed study. These areas are in the vicinities of Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi. This report is presented in eight volumes. This volume is a summary and discusses in general terms the procedures that were used to acquire the necessary quantitative terrain information and the techniques that were employed to adapt these data to displays that meet the specific requirements of cross-country locomotion analysis. Data collection, reduction and analysis procedures, and techniques for mapping the specific factors of each factor family are presented in Volume II (Surface Composition), Volume III (Surface Geometry), Volume IV (Vegetation), and Volume V (Hydrologic Geometry). Data summaries are included as appendixes to the appropriate volumes. Air-photo interpretation techniques used to identify air-photo patterns of terrain features are presented in Volume VI. The method used to synthesize the factor-family maps into factor-complex maps for mobility purposes is presented in Volume VII. Map sets for each of the four factor families for the six study areas are presented in Volume VIII.

KEYWORDS: Mobility; Terrain analysis; Terrain classification; Terrain factor maps; Tropical regions; [Thailand]

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Unclassified
Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SURFACE COMPOSITION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume II of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)

Robert C. Wright
James R. Burns

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency; U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

This volume presents the methods used to collect, tabulate, and analyze basic data on surface composition of six selected Thailand study areas--Nakhon Savan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi. Fifteen mapping classes that expressed the different soil mass strength and soil surface strength conditions were established. The criteria used in isolating these classes were (a) that each class be identifiable using air-photo interpretation techniques and (b) that each class exhibit similar variations in strength with moisture content. Areas with equivalent trafficability characteristics in terms of the 15 map classes were delineated on 25 surface composition maps together covering the six study areas. This delineation was accomplished through interpretation of maps and air photos with control data in the form of field and laboratory information. The maps are presented in Volume VIII of this report. A compromise between the desired degree of mapping class refinement and that dictated by the photo-interpretation criteria was necessary because of the nature of the field data. During the mapping program when sample site data were extrapolated to unsampled areas, the degree of mapping refinement was of necessity only fair to low. It is recommended that additional studies be conducted on the use of air-photo identification techniques in classifying soil strength conditions. This approach is believed to be basically sound; however, more field verification of predicted values will help to determine the reliability of this approach.

KEYWORDS: Airphoto interpretation; Mobility; Surface composition factors; Surface composition mapping; Terrain analysis; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY: A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; SURFACE GEOMETRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume III of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)

William K. Dornbusch, Jr.

6. REPORT DATE September 1967	7a. TOTAL NO. OF PAGES 214	7b. NO. OF REFS 5
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c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Service Agent: U. S. Army Materiel Command Washington, D. C.	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Washington, D. C.

13. ABSTRACT

This volume presents the methods used to collect, tabulate, and analyze basic data on the surface geometry of selected areas in Thailand. The descriptions of surface geometry features are so designed that the descriptive values can be used directly as input to an analytical model for predicting the cross-country speed of selected military vehicles. A method for classifying, interpreting, and mapping surface geometry factors from aerial photographs (air photos) was developed. Utilizing the field data collected and the air-photo interpretation methods developed, 25 surface geometry factor-family maps were prepared, together covering six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Pran Buri, Khon Kaen, and Chanthaburi). These mpas are presented in Volume VIII of this report. Air-photo interpretation methods for predicting and mapping surface geometry factors were largely successful. However, the degree of accuracy achieved for each of these factors varied considerably, being a function of the scale, quality, and vintage of the existing photography. It is recommended that studies be continued to develop air-photo interpretation techniques to improve the reliability of estimation of surface geometry factor values.

KEYWORDS: Airphoto interpretation; Mobility; Surface geometry factors; Surface geometry mapping: Terrain analysis; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; VEGETATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume IV of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)
Jerald D. Broughton
Eugene Addor

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

Vegetation characteristics were measured according to established sampling procedures at 295 sites within six areas of Thailand. From these samples, stem diameter and spacing data were extracted for analysis, since these are the factors that significantly affect performance of ground-contact vehicles. A dual classification system was devised for mapping these factors in which spacing values of 0-1.5 m, >1.5-3.0 m, >3.0-9.0 m, and >9.0 m were determined for stem diameters of 5 cm or less, 13 cm or less, 23 cm or less, and 130 cm or less, and stem diameters of 3 cm or more, 8 cm or more, 15 cm or more, and 25 cm or more. Map units were identified and delimited on aerial photographs by established photo-interpretation keys and techniques. Twenty-five 1:50,000-scale map sheets were prepared for the six study areas, on which 72 distinct mapping classes were identified. The vegetation field data for the six study areas are summarized in Appendix A.

KEYWORDS: Airphoto interpretation; Mobility; Terrain analysis; Tropical regions; Vegetation factors; Vegetation mapping; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U.S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY: A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; HYDROLOGIC GEOMETRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume V of report

5. AUTHOR(S) (First name, middle initial, last name)

Edgar E. Garrett
John H. Shamburger

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-726 Volume V
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

This volume presents the methods used in collecting hydrologic geometry data in selected areas in Thailand. The selection, analysis, and classification of parameters significant to vehicle mobility are discussed. The photo-interpretation methods used in identifying hydrologic geometry features from aerial photographs (air photos) and the extrapolation of these identifications to areas not investigated on the ground are presented. The rationale for cartographic portrayal of these parameters is explained. Utilizing the collected field data, available air photos, and the Army Map Service series of topographic maps, hydrologic geometry factor maps were prepared covering the six selected study areas (Nakhon Sawan, Lop Buri, Chiang Mai, Chanthaburi, Pran Buri, and Khon Kaen). The maps are presented in Volume VIII of this series. It proved only partially possible to determine the existence and value of the chosen parameters from air photos since some of the individual factors are wholly or partially below the water surface. Nevertheless, photo interpretation plus extrapolation from measured sites made it possible to map the parametric values by class range with reasonable validity. Recommendations are made involving improvement in data-collection techniques.

KEYWORDS: Airphoto interpretation; Hydrologic geometry factors; Hydrologic geometry mapping; Mobility; Terrain analysis; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE: MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR EVALUATING TERRAIN FOR GROUND MOBILITY; SELECTED AIR-PHOTO PATTERNS OF TERRAIN FEATURES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume VI of report

5. AUTHOR(S) (Last name, first name, initial)
Frost, Robert E., Johnson, Philip L., Leighty, Robert D., Anderson, Vernon H., Poulin, Ambrose O., and Rinker, Jack N.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Prepared for the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

This volume contains a catalog of photographs of Thailand terrain features described in such a way that the information can be used in making estimations of their effects on the performance of ground vehicles. Results of a limited study of the effects of film emulsion on the acquisition of terrain information from aerial photographs are also presented.

KEYWORDS: Aerial photographs; Airphoto interpretation; Mobility; Terrain analysis; Terrain factors; Tropical regions; [Thailand]

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	2b. GROUP

3. REPORT TITLE
MOBILITY ENVIRONMENTAL STUDY; A QUANTITATIVE METHOD FOR DESCRIBING TERRAIN FOR GROUND MOBILITY; DEVELOPMENT OF FACTOR-COMPLEX MAPS FOR GROUND MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume VII of an eight-volume report

5. AUTHOR(S) (First name, middle initial, last name)
William K. Dornbusch, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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c. ARPA Order No. 400	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Service Agency: U. S. Army Materiel Command, Washington, D.C.

13. ABSTRACT

Individual factor maps, devised as a product of the processes described in Volumes II, III IV, and V of this report, were compiled into a set of factor-family maps (surface composition, surface geometry, vegetation, and hydrologic geometry) by a process of sequential superpositioning. The factor-family maps were then compiled into two kinds of "factor-complex" maps: areal factor-complex maps, which display the areal extent of discrete combinations of factors value classes of three factor families (namely surface geometry, surface composition, and vegetation); and linear factor-complex maps, which display the occurrences of linear features (i.e., streams, canals, lakeshores, etc.) and the surface composition and vegetation immediately associated with them. Each discrete factor complex, whether areal or linear consists of a unique combination of factor value classes. Since the factors and factor value classes were chosen because of their significance to vehicle locomotion, it is presumed that each factor complex will affect vehicle performance in a specific and identifiable way. Because the data defining the factor complexes are precisely those required as terrain input values for the vehicle performance prediction model, the factor-complex maps furnish a comprehensive and concise data store for estimating the cross-country speeds of many military vehicles operating in terrains such as those of Thailand.

KEYWORDS: Mobility; Terrain analysis; Terrain factor maps; Terrain factors; Terrain mapping; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE
MOBILITY ENVIRONMENTAL RESEARCH STUDY; A QUANTITATIVE METHOD FOR EVALUATING TERRAIN FOR GROUND MOBILITY; TERRAIN FACTOR-FAMILY MAPS SELECTED AREAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume VIII of report

5. AUTHOR(S) (Last name, first name, initial)

6. REPORT DATE June 1966	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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c. ARPA ORDER NO. 400	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 487 500	
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10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency; Service Agency: U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

The terrain factor-family maps presented in this volume were prepared by four teams, each with responsibility for a factor family. The methods used and techniques developed to compile these maps are discussed by factor family in the following volumes of this report series: Volume II, Surface Composition; Volume III, Surface Geometry; Volume IV, Vegetation, and Volume V, Hydrologic Geometry.

KEYWORDS: Mobility; Terrain analysis; Terrain factor maps; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

FEASIBILITY STUDY OF THE USE OF RADAR TO DETECT SURFACE AND GROUND WATER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Davis, Billy R.
Lundien, Jerry R.
Williamson, Albert N., Jr.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Service Agent: U. S. Army Materiel Command, Washington, D. C. 20315	Advanced Research Projects Agency, Washington, D. C. 20315

13. ABSTRACT

A study was made of the feasibility of using radar sensors as a remote means of detecting the presence and measuring the depth of surface water, and detecting the presence and measuring the depth to ground water. Also, previously begun studies were continued to relate radar returns, and the electrical soil constants they provided, to soil moisture content. Large laboratory soil samples were prepared at various moisture contents and with various depths of surface water and various depths to ground water. Standard pulsed radar sensors operating with frequencies of 297, 5870, and 9375 megacycles per sec through various angles of incidence were employed. Results indicate that the standard pulsed radar sensors can provide information to permit detection of surface water and an estimate of the moisture content of deep homogeneous soil samples. However, such sensors do not permit prediction of depth of surface water, presence of ground water, or depth to ground water. Systematic variation of surface-water depths and depths to ground water permitted an analytical solution for measuring surface- or ground-water depths, and led to the conclusion that properly designed radar systems could measure surface- and ground-water depths. Three such systems are proposed.

KEYWORDS: Groundwater; Laboratory tests; Radar; Remote sensing; Soil moisture prediction; Soils; Surface water; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MECHANICS OF WHEELS ON SOFT SOILS; A METHOD OF ANALYZING TEST RESULTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Leflaive, E. M.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-14501-B-52A, Research in Earth Physics c. Task -01, Earth Physics, (Terrain Analysis) d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-729 Report 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 485 854

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

This report presents a method of analyzing the results of tests with pneumatic tires in sand. The method is based on considering the work of the pull developed by the test wheel as the difference between energy input and energy dissipation. The parameters used to represent these energies are defined, and their meanings are described in some detail by referring to the theoretical case of a rigid wheel on a rigid surface. This theoretical case is also used as a reference system to evaluate the results of actual tests. Experimental data for a number of representative test conditions are presented and compared with the reference system. Concepts of efficiency are introduced and discussed. It is concluded that the proposed approach is promising for both conveniently expressing experimental results and understanding tire behavior in soft soils. However, more data will have to be analyzed to draw quantitative conclusions for practical use. Four appendixes are included in which certain aspects of the definitions of slip, stress distribution, lateral confinement of sand, and criteria for propelling-system efficiency are discussed.

KEYWORDS: Laboratory tests; Pneumatic tires; Sands; Soil-wheel interaction; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclas. fied
	2b. GROUP

3. REPORT TITLE
MECHANICS OF WHEELS ON SOFT SOILS; EFFECT OF WIDTH ON RIGID WHEEL PERFORMANCE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)
Etienne M. Leflaive

6. REPORT DATE November 1967	7a. TOTAL NO. OF PAGES 30	7b. NO. OF REFS 2

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-729 Report 2
b. PROJECT NO. 1-V-0-14501-B-52A, Research in Earth Physics	
c. Task -01, Earth Physics (Terrain Analysis)	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Tests were run in an air-dried sand using three rigid wheels 28 in. in diameter and 12, 6, and 3 in. wide to determine the effect of wheel width on performance. Performance in this study was evaluated in terms of pull, torque, and dissipated energy. It was found that the width/diameter ratio influenced the rate of increase of torque energy at low slips, but at high slips, the slopes of the dissipated energy lines were approximately the same for all rigid wheels. An increase in load at a given high slip caused some changes in torque energy, and there was a load for which the torque energy was a minimum. The dissipated energy tended to increase with an increase in load, so the pull energy tended to decrease with an increase in load. Energy parameters measured in these tests with rigid wheels were compared with similar parameters from tests with pneumatic tires. In all cases, the pneumatic tire was found to be more efficient, with the better performance attributed mostly to a lower energy dissipation.

KEYWORDS: Laboratory tests; Pneumatic tires; Rigid wheels; Sands; Soil-wheel interaction; Trafficability; Wheel width

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
COMPARISON OF ENGINEERING PROPERTIES OF SELECTED TEMPERATE AND TROPICAL SURFACE SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Meyer, Marvin P.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research
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d. ARPA order No. 400

9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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11. SUPPLEMENTARY NOTES
Service Agent:
U. S. Army Materiel Command
Washington, D. C. 20315

12. SPONSORING MILITARY ACTIVITY
Advanced Research Projects Agency and
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT
Field and laboratory tests were conducted on 11 fine-grained soils from the temperate climate of the United States and 17 fine-grained soils from the tropical climates of Puerto Rico, Panama Canal Zone, Hawaii, and Thailand to determine the trafficability and other engineering properties of the soils. Soils were collected from the 6- to 12-in. layer for a wide range of parent materials. Temperate and tropical soils of each parent material were selected on the basis of their similarity in the Unified Soil Classification System and in topographic position. A comparison of physical, mineralogical, and chemical properties, and results of standard and special engineering tests indicate, with few exceptions, no significant differences between temperate and tropical soils from a similar parent material. It is concluded that temperate and tropical soils of similar parent material and Atterberg limits generally have other engineering properties that are similar and behave similarly when subjected to standard and special engineering laboratory tests. Differences in behavior between soils from each of the climates can be associated with differences in Atterberg limits.

KEYWORDS: Field tests; Laboratory tests; Parent materials (Soils); Soil property relations; Soil property variations; Temperate regions; Trafficability; Tropical regions; [Hawaii; Panama Canal Zone; Puerto Rico; Thailand; United States]

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3. REPORT TITLE

TRAFFICABILITY TESTS ON UNCONFINED ORGANIC TERRAIN (MUSKEG); SUMMER 1963 TESTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of series

5. AUTHOR(S) (Last name, first name, initial)

Rush, Edgar S.
Schreiner, Barton G.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-744, Report 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 805 328

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A program of trafficability tests was conducted in unconfined muskeg areas at Fort Wainwright, Alaska, with four tracked vehicles: an M116 amphibious cargo carrier, an M59 armored personnel carrier, an M41 combat tank, and an M60A1 combat tank. Self-propelled, go-no go tests were conducted with all four vehicles; maximum-drawbar-pull tests were conducted with the M116, the M59, and the M41; and cross-country speed tests were conducted with the M116 and M59. Results indicate that a combination of depth to permafrost and strength of the muskeg layer above permafrost affects vehicle performance on a go-no go basis. Average maximum drawbar pull of the M116 was 59% of its gross weight and apparently was limited by its torque converter output. The maximum pulls of the M59 and M41 ranged from 35 to 40% of their gross weights and were limited by traction capacity of the muskeg. In the cross-country tests, the speed of the M116 was greatly affected by the inability of the driver to see over the vegetation ahead of him. The reduction in speed of both the M116 and the M59 when traveling on muskeg, as compared with maximum speed on hard surfaces, may be attributed to increased motion resistance. Depth to permafrost was affected by surface cover; the shallowest permafrost was found generally under dense, woody vegetation, and the deepest permafrost was found generally in areas covered with grass and water or where all vegetation had been removed.

KEYWORDS: Field tests; Military bases; Military vehicles; Muskeg; Tracked vehicles; Trafficability; [Fort Wainwright, Alaska; M41; M59; M60A1; M116]

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3. REPORT TITLE

TRAFFICABILITY CLASSIFICATION OF THAILAND SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Meyer, M. P.

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13. ABSTRACT

Pertinent soil trafficability data were collected during the wet season at 846 sites in Thailand. The soils were identified according to the Unified Soil Classification System and the U. S. Department of Agriculture textural classification system. Two general topographic positions (high topography and low topography) and two general levels of wetness were considered. A scheme for classifying soils according to their trafficability was developed. The scheme lists the soil types in order of decreasing trafficability under each of three topography-wetness level categories and shows the probability of successful passage on each soil for vehicles of known soil strength requirements. The scheme permits the estimation of the probability of a successful operation for given soil type, topography, and wetness-level conditions. If a choice of several routes and vehicles is available, the determination of the vehicles with the best chances of success over a given route or of the best route for given vehicles can be made.

KEYWORDS: Soil properties; Statistical analysis; Trafficability classification; Trafficability data; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE: APPENDIX A: INSTRUMENTATION OF TEST VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency and U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

An instrumentation system was developed to measure and record the dynamic responses of a moving vehicle to discrete environmental factors. Measurements of force to override vegetation, drive-line torque, vehicle linear and wheel or track rotational displacement, fuel consumption, acceleration, pitch, and hydrostatic pressure were made to determine the effects imposed on the vehicle by soil and longitudinal, lateral, and vertical obstacles. The specific components of the system used for the various measurements are described and information concerning their positioning and operation is presented.

KEYWORDS: Field tests; Mobility; Terrain factors, Vehicle test instruments

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AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE; APPENDIX B: VEHICLE PERFORMANCE IN LATERAL AND LONGITUDINAL OBSTACLES (VEGETATION); VOLUME I: LATERAL OBSTACLES

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5. AUTHOR(S) (First name, middle initial, last name)
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Jack K. Stoll

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Advanced Research Projects Agency and Directorate of Development and Engineering, U. S. Army Materiel Command

13. ABSTRACT

A total of 95 lateral obstacle tests were conducted with two tracked and three wheeled vehicles at the NASA Marshall Space Flight Center, Miss., and Eglin Air Force Base, Fla. The principal conclusions from these tests were that (a) vehicle performance in terms of speed made good in an array of vegetation assemblages can be correlated with the density of vegetation assemblages expressed as mean obstacle spacing, (b) the minimum obstacle spacing required to permit movement of a vehicle can be computed from vehicle width, and (c) the speed made good a vehicle can achieve when maneuvering in lateral obstacles is significantly affected by the slope of the terrain. Methods of determining mean obstacle spacing from structural cell diameter and percent area denied from stem diameters of trees, vehicle width, and structural cell diameter are shown. A method of determining percent area denied by logs, mounds, and other obstacles is suggested.

KEYWORDS: Field tests; Military vehicles; Mobility; Mobility models; Performance tests (Vehicles); Vegetation factors; [Eglin AFB, Fla.; Marshall Space Flight Center, Miss.]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE
AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE;
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5. AUTHOR(S) (First name, middle initial, last name)
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Donald D. Randolph

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency and Development Directorate, U. S. Army Materiel Command

13. ABSTRACT

A total of 372 tests were conducted with one tracked and one wheeled vehicle at the NASA Marshall Space Flight Center, Miss., Eglin Air Force Base, Fla., Pran Buri, Thailand, and Khon Kaen, Thailand. The general purpose of these test was to obtain data relating characteristics of longitudinal obstacles to vehicle performance in terms suitable for use in developing that portion of the analytical model for cross-country performance. The specific purposes were (a) to determine the maximum horizontal force and total work required to override single standing trees of a range of sizes at various speeds and pushbar heights and (b) to determine average horizontal force and total work required to override trees in multiple array. Empirical relations are presented to support the conclusions that pushbar force required to fail trees singly and in mulitple array, work requires to fail trees singly and in multiple array, and work required to override a single standing tree may be predicted from stem diameter(s). A method is suggested for predicting work required to override trees in multiple array. The results of the tree-felling tests in the Tunguska meteorite area were confirmed, with a single exception noted, and discussed. It is recommended that additional testing be done in areas of soft soil to determine the effect of soil strength on uprooting, and in grass and brush areas to determine the effects of small vegetation on speed.

KEYWORDS: Field tests; Mathematical models; Military vehicles; Mobility; Mobility models; Performance tests (Vehicles); Tropical regions; Vegetation factors; [Eglin AFB, Fla.; Marshall Space Flight Center, Miss.; Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE; APPENDIX C: VEHICLE PERFORMANCE IN VERTICAL OBSTACLES (SURFACE GEOMETRY)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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Newell R. Murphy, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency and Directorate of Research, Development and Engineering, U. S. Army Materiel Command

13. ABSTRACT

This appendix presents a brief history of vehicle dynamics modeling, a recapitulation of the U. S. Army Engineer Waterways Experiment Station approach to the problem of predicting vehicle performance in terrain containing discrete vertical obstacles, and descriptions of dynamic response prediction models for the M60A1 tank and M37 truck, and compares measured and predicted vehicle performance in terms of peak vertical and longitudinal accelerations for 78 rigid obstacle tests with the two vehicles. Major conclusions from the tests were that performances of the M60A1 tank and M37 truck in terms of peak vertical and peak longitudinal accelerations experienced at the driver's seat when traversing discrete, rigid obstacles can be correlated with impact speed, that the mathematical techniques described yield reasonably accurate predictions of the speed at which the M60A1 tank can contact a rigid obstacle without exceeding specified tolerance limits, and that refinement is needed in the dynamic response prediction model for the M37 truck.

KEYWORDS: **Field tests; Military vehicles; Mobility; Mobility models; Performance tests (Vehicles); Surface geometry factors; Tanks (Combat vehicles); Trucks; [M37 truck; M60A1 tank]**

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3. REPORT TITLE
AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE; APPENDIX D: PERFORMANCE OF AMPHIBIOUS VEHICLES IN THE WATER-LAND INTERFACE (HYDROLOGIC GEOMETRY)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
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Beryl G. Stinson
Jack K. Stoll

6. REPORT DATE February 1970	7a. TOTAL NO. OF PAGES 45	7b. NO. OF REFS 7

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency and Directorate of Development and Engineering, U. S. Army Materiel Command

13. ABSTRACT
Forty tests were conducted with two amphibious tracked vehicles and one amphibious wheeled vehicle at Eglin Air Force Base, Fla., and near Khon Kaen, Thailand, to determine the vehicles' capabilities for exiting closed bodies of water. Empirical relations, based on the data collected in this study and in previous studies, are presented to support the conclusions that performance of amphibious tracked and wheeled vehicles (in terms of "go-no go") in the water-land interface can be correlated with soil strength (expressed as average cone index of the 0- to 6-in. soil layer), and that the slope-climbing ability in the water-land interface of the tracked vehicles tested compares favorably with that of the same vehicles operating on land surfaces of similar soil composition and consistency.

KEYWORDS: Amphibious vehicles; Field tests; Hydrologic geometry factors; Land-water interface; Mobility; Mobility models; Performance tests (Vehicles); Tropical regions; [Eglin AFB, Fla.; Thailand]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3 REPORT TITLE

AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE; APPENDIX E: QUANTIFICATION OF THE SCREENING EFFECTS OF VEGETATION ON DRIVER'S VISION AND VEHICLE SPEED

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5 AUTHOR(S) (First name, middle initial, last name)

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10 DISTRIBUTION STATEMENT

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency and Directorate of Development and Engineering, U. S. Army Materiel Command

13 ABSTRACT

A total of 39 tests were conducted with two wheeled and two tracked vehicles at three sites at Eglin AFB, Fla., and five sites at Khon Kaen, Thailand, in an effort to establish procedures for quantifying screening effects of vegetation on driver's vision and to relate recognition distance to maximum safe speed. Recognition distance was defined in this study as that distance wherein 76 percent of the dots painted on a standard target could be counted in a vegetation assemblage. Predictions of maximum safe speeds were computed based on recognition distance, and average deviation of predicted maximum safe speed from actual average speed for each test was 3.3 mph on the safe side. It is recommended that additional testing be done to develop a less tedious and time-consuming procedure for determining recognition distance in vegetated areas and that stopping distance-soil strength relations be established.

KEYWORDS: Field tests; Mobility; Mobility models; Performance tests (Vehicles); Tropical regions; Vegetation factors; Visibility; [Eglin AFB, Fla.; Thailand]

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3. REPORT TITLE

AN ANALYTICAL MODEL FOR PREDICTING CROSS-COUNTRY VEHICLE PERFORMANCE; APPENDIX F: SOIL-VEHICLE RELATIONS ON SOFT CLAY SOILS (SURFACE COMPOSITION)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Advanced Research Projects Agency and Directorate of Development and Engineering, U. S. Army Materiel Command

13. ABSTRACT

Sixty-six acceleration-deceleration tests were conducted with three wheeled and two tracked vehicles at five sites in Thailand. The principal conclusion from these tests was that vehicle deceleration in soft clay soils can be correlated with soil strength expressed as the average 0- to 6-in. cone index. The analysis indicated that acceleration increased with an increase in soil strength, but no definitive correlation could be established. Semiempirical and empirical relations were used in a first-generation analytical model to predict average speed over the test courses. Comparisons of measured and predicted speeds led to recommendations for specific additional studies to improve the reliability of the WES analytical model.

KEYWORDS: **Field tests; Military vehicles; Mobility; Mobility models; Performance tests (Vehicles); Soil strength; Surface composition factors; Trafficability; Tropical regions; [Thailand]**

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PILOT STUDY OF RESPONSE OF CV-2 AIRCRAFT TO IRREGULAR TERRAIN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
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Edgar S. Rush

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 3-790
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The investigation reported herein was a pilot study undertaken to develop means of predicting the performance of a CV-2 aircraft on irregular terrain and of quantifying surface roughness. Special tests were conducted to ascertain the natural frequency and damping characteristics in both the vertical and horizontal directions of the elements of the aircraft. Landing, takeoff, and taxi tests were conducted at 15 field sites in three general areas; accelerometers and strain gages were used to record responses of 12 critical components of the aircraft. Simple mathematical models to predict the dynamic responses of certain of the aircraft components were developed for solution by both analog and digital computers and were verified by comparison with measured data. Because of certain assumptions used in the development of the models, the predicted data did not agree exactly with the actual data. Although the predictions were of useful accuracy, it is recommended that an analog model, excited by measured terrain data, be used to determine the adequacy of a surface for landings of the CV-2 aircraft. To obtain the terrain input, an outrigger trailer dynamometer with an actual prototype aircraft tire as the terrain follower is proposed.

KEYWORDS: Aircraft landing areas; Computerized models; Microgeometry; Short takeoff and landing aircraft; [CV-2 aircraft]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
MOISTURE-STRENGTH CHARACTERISTICS OF SELECTED SOILS IN THAILAND
Vol I Analyses and Application of Data
Vol II Basic Data

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
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John G. Collins
Margaret H. Smith

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES Service Agent: U. S. Army Materiel Command, Washington, D. C. 20315	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Directorate of Remote Area Conflict Washington, D. C. 20315

13. ABSTRACT

Soil moisture, soil strength, and other relevant data were collected in Thailand during two wet seasons and one dry season for use in the development of methods to predict soil trafficability for off-road ground contact vehicles in Southeast Asia. Data were collected at 75 test sites distributed in eight geographic areas which had differences in soils, weather regimes, terrain, and land use.

From data collected monthly at the 75 sites, specific soil strength-moisture relations were derived to depict the changes in strength that corresponded to changes in moisture content. From data collected daily at 17 sites, specific soil moisture prediction relations were derived following procedures developed for sites in the United States. Results showed that the prediction methods were applicable to Thailand sites that were well drained. Modifications in the methods should be developed to account for the influence of water tables when present. Similarities in specific prediction relations between Thailand and the western hemisphere indicated that the development of average prediction relations is feasible.

Descriptions of Thailand and study areas are given in Appendix A. An application of the Thailand data, the derivation of a general soil moisture map for South Vietnam, is given in Appendix B. The basic data are summarized in Volume II.

KEYWORDS: Field tests; Soil moisture; Soil property relations; Soil strength; Terrain analysis, Trafficability; Trafficability data; Trafficability prediction; Tropical regions; Thailand

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3. REPORT TITLE

EVALUATION OF THE PERFORMANCE OF THE XM759 LOGISTICAL CARRIER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The XM759 was tested at sites in Virginia and Louisiana on a wide range of terrain conditions analogous to those of the Mekong Delta, South Vietnam. The off-road performance of the XM759 was compared with that of an M116, 1-1/2-ton Cargo Carrier, Amphibious, on the same test sites. An evaluation of the comparative performances of the XM759 and M116 in terms of terrain-vehicle relations (trafficability tests) and average speed for the terrain types tested (mobility tests) shows that the XM759 outperformed the M116 for most of the terrain conditions tested. Appendix A shows the computations necessary for determining VCI's of tracked vehicles. Appendix B presents a method for determining the effects of buoyancy on VCI's. Appendix C presents results of the terrain evaluation study to identify terrain types in several sections of South Vietnam and to locate similar areas in the Mississippi River Delta for vehicle test purposes.

KEYWORDS: Amphibious vehicles; Cargo vehicles; Field tests; Mobility; Temperate regions; Terrain analogs; Terrain analysis; Trafficability; Tropical regions; M116 cargo carrier; Mekong Delta; Mississippi River Delta; XM759 logistical carrier

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi		2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE DYNAMICS OF WHEELED VEHICLES; A MATHEMATICAL MODEL FOR THE TRAVERSAL OF RIGID OBSTACLES BY A PNEUMATIC TIRE		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Rpeort 1 of a series		
5. AUTHOR(S) (First name, middle initial, last name) Allan S. Lessem		
6. REPORT DATE May 1968	7a. TOTAL NO. OF PAGES 52	7b. NO. OF REFS 6
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Task 1-V-0-14501-B-52A-01 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-68-1, Report 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 834 324	
10. DISTRIBUTION STATEMENT Approved for Public Release; Distribution Unlimited		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.	

13. ABSTRACT

A mathematical model for a pneumatic tire was used to compute the horizontal and vertical forces transmitted through the tire to the vehicle axle to provide realistic force inputs for model studies of vehicle dynamics. The present model is valid for the computation of forces through a pneumatic tire traversing nondeforming obstacles, with zero slip. Laboratory tests are described in which static loaddeformation characteristics and dynamic obstacle-traversal characteristics were obtained. These tests were run with 9.00-14 tires under several conditions of ply rating and inflation pressure. Data from these tests were used to calculate model parameters and to produce time histories of dynamic responses. A computer implementation of the mathematical model is described which produced force and displacement time histories similar to those obtained during the obstacle-traversal laboratory tests. The model produced the essential features of the wave forms seen in the laboratory and is therefore a valid representation of a pneumatic tire for dynamic analysis of vehicles on nonyielding terrain.

KEYWORDS: Laboratory tests; Mathematical models; Obstacle-wheel interaction; Pneumatic tires; Ride dynamics; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
DYNAMICS OF WHEELED VEHICLES, Report 1; A MATHEMATICAL MODEL FOR THE TRAVERSAL OF RIGID OBSTACLES BY A PNEUMATIC TIRE; APPENDIX B: DIGITAL IMPLEMENTATION OF SEGMENTED TIRE MODEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Appendix B to final report

5. AUTHOR(S) (First name, middle initial, last name)
Newell R. Murphy, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

This appendix presents the procedures for digital implementation of the segmented tire model, developed in the basic report for an analog computer. Two procedures are required: (a) determination of the segment spring coefficient from measured load-deflection test results, and (b) computation of the resultant force vector transmitted to the axle. Digital programs for both procedures were written in Fortran IV for a GE-420 system, and are included.

KEYWORDS: **Computerized models; Obstacle-wheel interaction; Pneumatic tires; Ride dynamics**

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

DYNAMICS OF WHEELED VEHICLES; Report 2, IMPLEMENTATION OF WIENER-BOSE THEORY AND APPLICATION TO RIDE DYNAMICS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Allan S. Lessem

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Report was also submitted as thesis for degree of Doctor of Philosophy in Engineering to Mississippi State Univ., State College, MS. Presented at Proceed. I VS/TRW Symp., Nov 1970.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Wiener-Bose Theory is a strategy for identifying nonlinear systems in terms of a set of "characterizing coefficients." A computer study was conducted to discern problems of implementation of the theory. Several systems of increasing complexity were studied and a practical form of Wiener-Bose Theory evolved. The systems studied were as follows: (a) a zero-memory system, (b) rate-independent hysteresis, (c) a second-order system with saturation, and (d) a fourth-order mechanical system with nonlinear compliances. A military M37, 3/4-ton truck was selected for characterization using a Wiener-Bose model having 1024 coefficients. The characterizing coefficients were obtained by utilizing the responses of the vehicle recorded during traversal of a specially configured obstacle course whose total length was 2.5 miles. Once the coefficients were obtained, they were used to synthesize responses to specific terrain profiles. These predicted responses compared favorably with counterpart responses of the vehicle traversing the same profiles. It was concluded that Wiener-Bose Theory is capable of satisfactory performance in the analysis of many nonlinear systems. The principal difficulty in its practical application is the extensive probing effort required for characterizing the system.

KEYWORDS: Mathematical models; Mobility; Mobility numbers: Nonlinear systems; Ride dynamics; Trucks

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

DYNAMICS OF WHEELED VEHICLES; Report 3, A STATISTICAL ANALYSIS OF TERRAIN-VEHICLE-SPEED SYSTEMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 3 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Newell R. Murphy, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES Report was also submitted to Mississippi State University, State College, Mississippi as thesis for degree of Master of Science in Engineering	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Digital computer simulations were conducted in which a vehicle was run at several selected speeds over terrain profiles with various levels of roughness. The terrain profiles were generated by computer programs that constructed and shaped sequences of random normal numbers to provide representative profiles with a desired power spectrum, variance, mean value, standard deviation, and RMS. These programs also performed the necessary statistical checks for normality, stationarity, and randomness. A comprehensive, nonlinear mathematical model of an M37 truck served as the vehicle. This model allowed for the nonlinearities inherent in large rotational motions, the suspension eleements, bump stop, loss of ground contact, and the tire compliance, which was represented by a cluster of radially projecting springs. The results are presented in the form of three basic graphs comparing input and output statistics and distribution functions. The input statistics consisted of terrain roughness as measured by RMS elevation. The output is represented as the RMS vertical acceleration of the vehicle's center of gravity. A family of curves was developed relating vehicle response to terrain roughness for each speed of vehicle traversal. Cross plots of these established relations provided a more useful relation between vehicle response and speed for various degrees of terrain roughness.

KEYWORDS: Computerized models; Mobility; Mobility models; Ride dynamics; Statistical analysis; Trucks; Vehicle speed; [M37 truck]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
DYNAMICS OF WHEELED VEHICLES; Report 4, A STATISTICAL ANALYSIS OF OBSTACLE-VEHICLE-SPEED SYSTEMS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Gerald G. Switzer

6. REPORT DATE March 1972	7a. TOTAL NO. OF PAGES 53	7b. NO. OF REFS 7
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT
Approximately 300 tests were conducted with an M37 3/4-ton truck at various speeds over single obstacles of various heights and shapes. Data for acceleration-time history, vehicle speed and pitch angle, and event markings were recorded on FM analog tape, which was processed by an analog computer (described in Appendix A). The following parameters were determined (at the vehicle center of gravity) for each test: (a) peak, root mean square, and mean root mean square values of vertical acceleration, and the vector sum of vertical and longitudinal acceleration components; and (b) vehicle impact speed and average speed during obstacle traversal. Linear correlations of vehicle average speed with peak and statistical accelerations were determined by regression analysis. From the corresponding coefficients of determination, the statistical values were found to exhibit a much higher degree of correlation with vehicle average speed than did the peak values. A series of constant-condition tests revealed that the statistical descriptors of vehicle response were superior to peak values in terms of repeatability. A strategy was devised for displaying test results in compact graphic form, which is useful for predicting vibration severity caused by traversal of single obstacles and can be included easily in comprehensive models of vehicle mobility. Statistical and peak acceleration values were compared with corresponding values obtained from an analytical simulation of the M37 truck to determine whether statistical descriptors can be used to validate analytical models. Further model testing will be required before conclusions can be drawn.

KEYWORDS: Computerized models; Field tests; Mobility; Ride dynamics; Statistical analysis; Trucks; Vehicle speed; [M37 truck]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

CONTRIBUTION TO THE MECHANICS OF RIGID WHEELS ON SAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus Wiendieck

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Current theoretical concepts of soil-running gear interaction are based on empirical pressure-sinkage and shear stress-displacement relations. However, tests from which these relations were obtained present a poor analogy to the soil-running gear interaction. Sela's theory of the relation between rigid wheel and dry sand is based exclusively on the shear stress-displacement concept, and this provides an excellent means of checking the concept. Using a simple approximate relation between the M/RW ratio and the mean shear-to-normal stress ratio (τ/σ) taken over the total contact surface, the theory was checked by means of constant-slip rigid-wheel tests. Results stongly supported the conclusion that shear-displacement relations are irrelevant to soil-wheel mechanics. A new theory was developed that attempts to assess the variation of τ/σ along the soil-wheel interface, without referring to stress-displacement relations. It uses the soil rupture pattern beneath rigid wheels on sand to subdivide the total interface into three zones of different soil behavior. This theory agrees better with test data than other theories.

KEYWORDS: Rigid wheels; Sands; Soil-wheel interaction; Stresses under wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

IMPROVED WHEEL PERFORMANCE ON SAND BY CONTROLLED CIRCUMFERENTIAL RIGIDITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus W. Wiendieck

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Assistant Secretary of the Army (R&D) Department of the Army

13. ABSTRACT

An analysis of experimentally determined stress distributions beneath tires on sand revealed a strong tendency for the normal stresses to be greater in areas of higher-than-average tire rigidity, i.e. along the periphery of the contact patch where the tire rigidity is augmented by tire sidewall stiffness and/or local tire flexing. The question arose as to whether the observed phenomenon could be used advantageously by directly controlling the tire rigidity pattern, and thus favorably influence stress distribution, with the net result of improved tire performance. An experimental wheel was built to test this principle; its performance is described in this report. The control of local tire rigidity was achieved by a system of six nonrotating hydraulic jacks inside the wheel acting against a fixed flexible shoe, along which the inner surface of the tire slid as it rotated. Tests with sand at two strength levels showed that the wheel with favorable rigidity distribution (increasing rigidity to the rear of the soil-wheel interface) developed up to [illegible] percent more pull than the wheel with unfavorable rigidity distribution. The greater pull was paralleled by an efficiency increase of the same order. These experimental results are explained by theoretical computations based on the variation of assumed stress distribution as a function of the rigidity pattern. The experimental wheel was built to check a principle rather than to be used as a means of locomotion, but the prospect of applying the principle of controlled rigidity in practice is shown to be promising.

KEYWORDS: Pneumatic tires; Sands; Stress distribution; Stresses under wheels

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1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE BASIC SINKAGE EQUATIONS AND BEARING CAPACITY THEORIES

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Final report

5. AUTHOR(S) *(First name, middle initial, last name)*

Mikael J. Hvorslev

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046 c. Task 03 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-70-1 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)* AD 869 015

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The results of plate-sinkage tests for normal loads and corresponding load-sinkage relations for towed vehicles are frequently expressed by the simplified sinkage equation $p = kz^n$, where p is the unit load or pressure, z the sinkage, k the sinkage modulus, and n the sinkage exponent. It is shown that this equation does not satisfactorily represent the results of routine plate-sinkage tests in a plastic clay and in a fine cohesionless sand performed at WES. Expanded theories for bearing capacity of soils are reviewed and used to derive dimensionless pressure-sinkage relations for normal loads, taking size, shape, and depth of the loaded area into consideration. The trends revealed by these equations are partially substantiated by the test data, but significant deviations occur, especially with increasing depth-diameter ratios of plates in sand. The expanded bearing capacity equations indicate that the tangential components of inclined loads encountered beneath powered wheels and in plate-shear tests may cause failure in bearing capacity and corresponding large additional sinkages before the peak shear strength of the soil in the contact area is attained. WES tests with ribbed shear plates also show that failure along inclined planes at the ribs may occur at low normal loads before the full shear strength is attained in horizontal planes beneath the ribs. The effect of these occurrences on interpretation of the test data is discussed. Recommendations are made for further research to determine the influence of size, shape, and depth of the loaded area and of a load inclination on the load-sinkage relations.

KEYWORDS: Dynamic bearing capacity; Plate bearing tests; Pressure-sinkage relations; Vehicle sinkage

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE EVALUATION OF WHEELS FOR LUNAR VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Dean R. Freitag
Andrew J. Green
Klaus-Jurgen Melzer

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Summary of this report is reported in U. S. Army Engineer Waterways Experiment Station M. P. No. M-70-4	George C. Marshall Space Flight Center National Aeronautics and Space Administration, Huntsville, Alabama

13. ABSTRACT

One pneumatic wheel, four metal-elastic wheels, and two instrumented vehicles were laboratory tested in a fine sand to determine their relative performance and to establish a better understanding of the basic principles of the interaction of very lightly loaded wheels with a soil whose properties were varied to include the probable range of lunar soil properties. Programmed-slip tests were conducted with the single wheels and the vehicles, the latter being tested on both slopes and level surfaces. Data indicate that for loads less than about 220 N (50lb), the pull/slope-climbing ability was constant for a given soil condition. At greater loads, the rate of increase in performance decreased. The effect of cohesion on performance was negligible at loads less than about 220 N (50 lb), but the effect could be seen at higher loads. The results of t[illegible] with the metal-elastic wheels showed that none could be relied on to propel a ve[illegible]e up a 35-deg slope. Modifications of the Bendix and Grumman wheels enhanced their performance to the point that they might be expected to climb slopes in excess of 30 deg. Tests with modified Boeing-GM wheels indicated that they might be used on slopes up to about 25 deg on certain soil conditions. The power required, in whr/km, for operation of the wheels on level and sloping soil surfaces was determined. It was demonstrated that data from single-wheel tests can be used to predict the slope-climbing ability of a vehicle; such predictions tend to be slightly conservative. Results of tests with the vehicles indicate that the torque coefficient at a given slip was not significantly affected by variations in surface slope and soil strength.

KEYWORDS: Laboratory tests; Lunar roving vehicles; Sands; Soil-wheel interaction; Trafficability; Wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
EVALUATION OF WES ANALYTICAL MODEL IN SELECTED TERRAINS (XM559E1 GOER TESTS AT CAMP GAGETOWN, NEW BRUNSWICK, CANADA)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Beryl G. Stinson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Tank-Automotive Command Warren, Michigan

13. ABSTRACT

This study was conducted to (a) evaluate the performance of the 8-ton XM559E1 GOER when operating in selected Canadian terrains and (b) evaluate the capability of the WES analytical model to predict the performance of an 8-ton XM559E1 in selected Canadian terrains. Speed and motion resistance tests on secondary roads, cross-country speed tests, drawbar pull-slip tests, and towed off-road motion resistance tests were conducted. Where pertinent, soil, surface geometry, and vegetation data were collected before or after each test, and speed, vertical and longitudinal accelerations, percent wheel slip, and drawbar pull were measured. A comparison was made of actual performance and performance as predicted by the analytical model. The average of the absolute deviation of actual from predicted speeds for the tests conducted was 1.36 mph.

KEYWORDS: Field tests; Goer vehicles; Mathematical models; Military bases; Military vehicles; Mobility; Mobility models; Performance predictions; Performance tests (Vehicles); Terrain factors; [Camp Gagetown, Canada; XM559E1 Goer]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

RELATIVE OFF-ROAD MOBILITY PERFORMANCE OF SIX WHEELED AND FOUR TRACKED VEHICLES IN SELECTED TERRAIN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

J. K. Stoll
D. D. Randolph
A. A. Rula

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The U. S. Army Engineer Waterways Experiment Station analytical model for predicting off-road ground mobility was used to evaluate the performance of six wheeled vehicles (M656, M54A2, M520, M37B1, M561, and M706) and four tracked vehicles (M548, M113A1, M116 and M571) over a selected traverse in Thailand. Maps were prepared to exhibit the terrain in terms of surface composition (soil consistency), surface geometry (slopes, rice-field dikes, etc.), vegetation, and hydrologic geometry (rivers and streams). The performance of each vehicle was evaluated in terms of average speed over the traverse and the center line, average fuel consumed over the traverse, and center-line cargo delivery rate. The vehicles were "run" over the traverse under dry-season conditions (60 or 40 rating cone index) and wet-season conditions (60 or 35 rating cone index). Four of the vehicles (M656, M54A2, M520, and M548) were tested also under wet-season conditions of 60 or 40 rating cone index. Appendix A describes the WES analytical model in an abbreviated form; Appendix B, the evaluation of the dynamic response of the M706; and Appendix C, some additional general analyses of the effects of soil strength on vehicle performance.

KEYWORDS: Field tests; Military vehicles; Mobility; Performance predictions; Terrain factors; Tropical regions; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
PERFORMANCE OF RIVERINE UTILITY CRAFT (RUC) IN RIVERINE ENVIRONMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
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Robert P. Smith
Charles E. Green

6. REPORT DATE April 1970	7a. TOTAL NO. OF PAGES 89	7b. NO. OF REFS 6
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Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Naval Ship Systems Command Department of the Navy Washington, D. C. 20360

13. ABSTRACT Tests were conducted at four riverine sites in south Louisiana in November 1969 to evaluate the performance of the Riverine Utility Craft (RUC). The RUC is an amphibian that employs a locomotion concept based on the Archimedean screw. It moves by two counterrotating rotors that give forward and backward thrust; the rotors also serve to float the craft. The RUC is powered by two 380-hp engines and is designed to carry a payload of 2000 lb; the gross weight of the RUC is 13,000 lb. Specific purposes of the tests were to (a) develop performance-soil strength (rating cone index) relations in terms of maximum straight-line speed, maximum maneuver speed, and minimum time required to turn 180 deg, (b) determine water-exit capabilities, (c) determine the speed attained in a variety of test courses and terrain types commonly found in wetland marshes, and (d) determine the degree of analogy of the terrain types tested with terrain types at selected areas of the Mekong Delta, South Vietnam. The specific purposes of the test program were satisfied. Test results indicate that, in general, the RUC can operate in the riverine environments for which it was designed. The craft's performance is most effective in water and wet marshes of low soil strength. The RUC also has a performance capability in areas considered restrictive or even inaccessible to boats and other amphibious craft. Appendix A discusses the comparison of terrain types tested during the RUC program with those identified in selected areas of the Mekong Delta. Appendix B presents detailed descriptions of soil profiles along the Louisiana test courses.

KEYWORDS: Buoyant screw vehicles; Field tests; Hydrologic geometry factors; Mobility; Performance tests (Vehicles); Stream crossings; Trafficability; [Louisiana; Riverine Utility Craft

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP

3. REPORT TITLE

Quantitative Description of Selected West German Terrain for Ground Mobility

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report.

5. AUTHOR(S) (First name, middle initial, last name)

H. K. Woods
J. H. Shamburger

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Ballistic Research Laboratory Aberdeen Proving Ground Maryland

13. ABSTRACT

This study was performed to classify and map terrain for ground mobility purposes in accessible areas of three German military reservations (Baumholder, Bergen-Hohne, and Grafenwohr). The terrain was classified in terms of surface geometry, surface composition, vegetation, and hydrologic geometry factors that affect vehicle mobility. Mapping of the terrain factors was accomplished through interpretation of air photos. To provide the necessary ground control data for photo-interpretation processes, a field data collection program was conducted, and data were collected according to established procedures. The field data were tabulated and placed in established class ranges significant to ground mobility. Utilizing the field data, an air photo interpretation method was applied to estimate the established terrain factor-value classes from the geometric, tonal, and textural characteristics of the air photo patterns. Terrain characteristics were extrapolated from the sample to the unsampled areas, and factor-family maps at a scale of 1:25,000 were prepared of the three study areas. The factor-family maps were then compiled into areal and linear factor-complex maps. The areal factor-complex maps display the areal extent of discrete combinations of factor-value classes of surface geometry, surface composition, and vegetation factor families. The linear factor-complex maps display the factor values of linear features (i e. streams, canals, road embankments, etc.) and the surface composition and vegetation associated with them.

KEYWORDS: Airphoto interpretation; Mobility, Temperate regions; Terrain analysis; Terrain classification; Terrain factor maps; Terrain mapping; [West Germany]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Evaluation of the Relative Off-Road Performance of 15 Vehicles in Synthalogous Theaters of Operation (STOP) Terrain Factor Complexes

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

A 2-volume report; Vol 2 contains data only

5. AUTHOR(S) (First name, middle initial, last name)

D. D. Randolph

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10. DISTRIBUTION STATEMENT

Approved for Public Release; Distribution Unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The purpose of this study was to evaluate the performance of ten wheeled and five tracked vehicles in the areal terrain factor complexes of the synthalogous (a coined word meaning "synthetic and analogous") theater of operations (STOP) using the U. S. Army Engineer Waterways Experiment Station (WES) analytical model.

Input data used by the model were (a) terrain data, (b) vehicle characteristics and performance data, and (c) terrain-vehicle performance relations.

Predictions were made in terms of speed, fuel consumption rate, and delivery rate for each vehicle in each areal terrain factor complex of the temperate, tropical, and arid climates of the STOP during the dry and wet seasons.

A two-volume report was prepared. Volume I contains the application of WES analytical model for evaluating vehicle performance in STOP terrain complexes, and Appendix A, which describes the analytical model. Volume II contains Appendices B, C, and D, which give the vehicle performance predictions determined by the analytical model for the tropical, arid, and temperate climate theaters, respectively.

KEYWORDS: Desert regions; Military vehicles; Mobility; Mobility models; Performance predictions; Synthalogous environment; Temperate regions; Terrain analysis; Terrain factors; Tropical regions

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3 REPORT TITLE

A PRELIMINARY STUDY OF SEAFLOOR TRAFFICABILITY AND ITS PREDICTION

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (First name, middle initial, last name)

Klaus W Wiendieck

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10 DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	U S. Naval Civil Engineering Laboratory Port Hueneme, California

13 ABSTRACT

In anticipation of the growing need for various types of seafloor-crawling vehicles, problems of seafloor trafficability and of its prediction are outlined The qualitative comparison between trafficability-related land and seafloor features showed that soft-soil mobility is the central problem for seafloor-crawling vehicles. Therefore, the soft-soil mobility problem was given the strongest emphasis within the state-of-the-art review, which includes a discussion of existing seafloor-crawling vehicles The relative merits of the existing basic running gears are discussed and weighted with respect to different mission profiles and seafloor characteristics, and four (wheel, track, hanging chain, and sled) selected as prime contenders. A largely laboratory-confined test program with these four running gears is outlined to respond to the problems of immediate concern. (a) applicability of existing land trafficability prediction techniques to seafloor trafficability prediction and (b) determination of go-no go criteria, which, for practical reasons, must be related to the response of remotely operated seafloor probing devices. A free-falling two-part cone penetrometer is proposed for this latter purpose.

KEYWORDS: Mobility; Ocean bottom vehicles; Trafficability prediction; Underwater vehicles

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
RELATIVE OFF-ROAD MOBILITY OF MBT70 AND M60A1E1 TANKS IN SELECTED TERRAINS IN WEST GERMANY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
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Claude A. Blackmon
Beryl G. Stinson
Jack K. Stoll

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10. DISTRIBUTION STATEMENT
Distribution limited to U. S. Government agencies only; test and evaluation; 22 Jan 1974. Other requests for this document must be referred to U. S. Army Engineer Waterways Experiment Station.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Ballistics Research Laboratories. Aberdeen Proving Ground, Md. and U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT
The speeds of the MBT70 and the M60A1E1 tanks over two selected traverses in West Germany were predicted by use of an analytical model. Vehicle performance relations extrapolated from previous field tests with similar vehicles and from terrain data (surface geometry, surface composition, vegetation, and hydrologic geometry) collected along and adjacent to the selected traverses were used in the analysis. The analytical model is described briefly, and the development of the vehicle-terrain relations necessary to make speed predictions over the traverses selected is discussed in detail. The application of the analytical model, the division of the traverses into discrete sections, the factors affecting speed in each section, and the prediction of the speed for each section are explained. A comparison of the predicted speeds for the two vehicles indicates the MBT70 to have the higher speed. It is suggested that actual field tests be conducted with the vehicles, when practical, to determine the accuracy of the predictions and to improve the quality of the relations used in the analytical model. Appendixes A, B, C, and D describe the determination of the minimum soil strength on which the vehicles can operate, the classes used to describe terrain for ground mobility purposes, the computer program used to predict dynamic response of the vehicles, and the effect of the driver's position on speed of the M60A1E1 over abrupt surface irregularities, respectively.

KEYWORDS: Mathematical models; Military vehicles; Mobility; Mobility models; Performance predictions; Tanks (Combat vehicles); Terrain factors; Vehicle speed; [Germany; M60A1E1 tank; MBT70 tank]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY EXERCISE A (MEXA) FIELD TEST PROGRAM; REPORT 2, PERFORMANCE OF MEXA AND THREE MILITARY VEHICLES IN SOFT SOIL, Volume 1

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Volume I of Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Barton G. Schreiner

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

In the concept phase of Mobility Exercise A (MEXA) the principal purpose was to design vehicles capable of operating in remote areas of the world where extremely soft soils predominate, and to develop a program of tests for evaluating these vehicles in soft soils. As a result of the MEXA concept phase, two 2-1/2-ton wheeled and one 2-1/2-ton tracked vehicles were designed. The designs of the vehicle characteristics were in part derived from the U. S. Army Engineer Waterways Experiment Station (WES) soil trafficability system, the WES mobility numeric system, and the Land Locomotion Laboratory soil value system. After the MEXA vehicles were fabricated, a field test program was designed and conducted. A total of 328 tests were conducted on level clay soils at two sites near Vicksburg, Miss., and at eight sites near Fallon, Nev. The purpose of the test program was to evaluate the performance of the three MEXA vehicles (MEXA 10x10, MEXA 8x8, and MEXA track) and three military vehicles (XM410E1, M35A2 (mod), and M113) on a range of soil strengths. Further purposes of this study were to compare the performances of the three MEXA vehicles with those of the three military vehicles and to compare the measured and the predicted performances of the vehicles, using the three prediction systems from which the MEXA vehicles were designed. The measured and predicted performance comparisons are presented in Appendixes A, B, and C, Volume II. Test results indicate that the MEXA vehicles do what they were designed to do, i.e. perform better on soft soils than military vehicles. However, on firm soil and on pavement, performance is not as good.

KEYWORDS: Field tests; Military vehicles; Mobility; Performance predictions; Trafficability; Vehicle design;[Mobility Exercise A; Nevada; Vicksburg, Miss.]

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	2b. GROUP

3. REPORT TITLE
MOBILITY EXERCISE A (MEXA) FIELD TEST PROGRAM; Report 3, PERFORMANCE OF MEXA AND THREE MILITARY VEHICLES IN LATERAL OBSTACLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 3 of a series

5. AUTHOR(S) (First name, middle initial, last name)
Joseph L. Decell

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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

The purpose of this study was to develop pertinent vehicle-lateral obstacle relations for three vehicle test beds (MEXA vehicles) and three conventional military vehicles all having approximately the same payload and to compare the performances of the MEXA vehicles with those of the conventional vehicles. An additional purpose was to develop a method of predicting the speed of a vehicle maneuvering in lateral obstacles. The vehicles were tested on a firm, level surface upon which was imposed a statistically designed array of obstacles at mean spacings of 14, 16, 18, and 20 ft. In 78 of the 118 tests conducted, continuous measurements were made of vehicle speed, drive-line torque, and steering angle. In all tests, measurements were made of time elapsed and distance traveled. The data collected permitted the development of useful relations between vehicle width and minimum obstacle spacing negotiable, vehicle speed and obstacle spacing, vehicle steering angle and obstacle spacing, and vehicle speed and obstacle clearance. These relations were used to develop a simple method for relating the maximum speed a vehicle can develop to obstacle spacing that required only a knowledge of the vehicle width and its speed-traction characteristics on a firm surface. The conventional vehicles traveled faster and required less arduous steering than the MEXA vehicles. The maximum spacing required by each vehicle appeared to be a direct function of its width; all vehicles required the same minimum clearance on the driver's side. Appendix A describes the use of speed-obstacle spacing relations as input data for an analytical model

KEYWORDS: Field tests; Military vehicles; Mobility; Obstacles; Performance predictions; Performance tests (Vehicles); Surface geometry factors;[Mobility Exercise A]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY EXERCISE A (MEXA) FIELD TEST PROGRAM; Report 4, PERFORMANCE OF SELECTED MEXA AND MILITARY VEHICLES IN VERTICAL OBSTACLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Newell R. Murphy, Jr.
Adam A. Rula

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Fifty tests were conducted with two vehicles, an XM410E1, 8x8, 2-1/2-ton cargo truck and the MEXA 10x10, 2-1/2-ton, wheeled, articulated test bed. The vertical obstacle test course at WES, on which rigid, single or multiple obstacles of various heights and shapes can be tested, was used. The primary purpose of these tests was to obtain data to relate obstacle height, vehicle speed, and vertical acceleration (at selected locations on the vehicle) for use as input to the AMC-71 cross-country mobility prediction model. A secondary purpose was to provide data for use in verifying the vehicle dynamics prediction models using test data for the XM410E1 and MEXA 10x10. Results of the test are presented by curves relating, for a series of obstacle heights, the speed of the vehicle at contact with the obstacle versus peak accelerations at selected locations on the vehicle, and obstacle height versus speed for a vertical acceleration of 2.5 g's in the driver's compartment and vehicle center of gravity. Test data are compared with predicted results obtained from the dynamic response computer models for both vehicles. The results indicate among other things that: (a) the intensity of vertical acceleration depends on the location in the vehicle; (b) human tolerance levels are reached only for vertical accelerations; (c) tire pressure can significantly affect peak acceleration relations; (d) for a given level of acceleration, speed decreases with an increase in obstacle height; and (e) with proper input the mathematical models can be used to adequately simulate speed-obstacle height relations.

KEYWORDS: Cargo vehicles; Field tests; Military vehicles; Mobility; Obstacles; Performance predictions; Performance tests (Vehicles); Ride dynamics; Surface geometry factors; [Mobility Exercise A]

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DOCUMENT CONTROL DATA - R & D

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY EXERCISE A (MEXA) FIELD TEST PROGRAM; Report 4, PERFORMANCE OF SELECTED MEXA AND MILITARY VEHICLES IN VERTICAL OBSTACLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Newell R. Murphy, Jr.
Adam A. Rula

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Fifty tests were conducted with two vehicles, an XM410E1, 8x8, 2-1/2-ton cargo truck and the MEXA 10x10, 2-1/2-ton, wheeled, articulated test bed. The vertical obstacle test course at WES, on which rigid, single or multiple obstacles of various heights and shapes can be tested, was used. The primary purpose of these tests was to obtain data to relate obstacle height, vehicle speed, and vertical acceleration (at selected locations on the vehicle) for use as input to the AMC-71 cross-country mobility prediction model. A secondary purpose was to provide data for use in verifying the vehicle dynamics prediction models using test data for the XM410E1 and MEXA 10x10. Results of the test are presented by curves relating, for a series of obstacle heights, the speed of the vehicle at contact with the obstacle versus peak accelerations at selected locations on the vehicle, and obstacle height versus speed for a vertical acceleration of 2.5 g's in the driver's compartment and vehicle center of gravity. Test data are compared with predicted results obtained from the dynamic response computer models for both vehicles. The results indicate among other things that: (a) the intensity of vertical acceleration depends on the location in the vehicle; (b) human tolerance levels are reached only for vertical accelerations; (c) tire pressure can significantly affect peak acceleration relations; (d) for a given level of acceleration, speed decreases with an increase in obstacle height; and (e) with proper input the mathematical models can be used to adequately simulate speed-obstacle height relations.

KEYWORDS: Cargo vehicles; Field tests; Military vehicles; Mobility; Obstacles; Performance predictions; Performance tests (Vehicles); Ride dynamics; Surface geometry factors; [Mobility Exercise A]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE PENETRATION RESISTANCE OF SOILS; Report 1, TESTS WITH CIRCULAR FOOTINGS IN AIR-DRY SANDS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 1 of a series	
5. AUTHOR(S) (First name, middle initial, last name) Andrew J. Green	

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Assistant Secretary of the Army (R&D) Department of the Army Washington, D. C.

13. ABSTRACT

The study reported herein is an analysis of the penetration of circular plates and smooth-walled and rough-walled cylinders in two sands, each prepared at three strength levels. The penetration elements ranged from 2.5 to 61 cm in diameter, and the speed of penetration in all tests was 2.5 mm/sec. No basic differences were found in the shape of the penetration resistance curves for plates and cylinders, and the forces on the base of the cylinders were only slightly higher than those on the plates. The forces due to friction on the sidewalls of the cylinders were greater for the rough-walled cylinders than for the smooth, as could be expected, but they did not vary systematically with sand density in either case. Collapse of the data into a single function for sand was achieved by plotting a dimensionless pressure parameter $P/\gamma d$ versus a penetration parameter z/d. This gave evidence that pressure-sinkage relations, and thus bearing capacity, of large footings can be predicted from model tests. Dimensionless scaling relations and theoretical equations that include a friction angle term were also found to predict bearing capacity, but the problems in measuring a true friction angle make the use of these relations questionable for this purpose. The tests were deemed successful and eliminated irregularities encountered in the results of routine tests. The data should also be of great value in investigations of depth factors for bearing capacity of sand. This report will be supplemented by a report on similar tests in clay.

KEYWORDS: Footings; Penetration resistance (Soils); Sands; Soil penetration tests

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

PENETRATION RESISTANCE OF SOILS; Report 2, GAMMA-RAY TECHNIQUES FOR NONDESTRUCTIVE MEASUREMENTS OF SOIL DENSITY AND DENSITY PROFILE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Albert N. Williamson, Jr.

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Assistant Secretary of the Army (R&D) Department of the Army Washington, D. C.

13. ABSTRACT A study was conducted to determine the feasibility of using measurements made with a multichannel gamma-ray spectrometer and a cobalt 60 radiation source for accurately determining soil density and resolving the density profile of layers. Measurements were first made on aluminum and steel plates to establish a standard reference for comparing soil density. Two samples of air-dry sand were constructed at different densities to a depth of approximately 120 and 125 cm in a pit 51.82 m long and 3.54 m wide. Measurements were made at depth intervals of 12.7 cm in each of six access holes located in the samples. The densities determined were compared with densities determined by nonnuclear means. Results of this study indicate that density can be measured accurately by the method described herein provided (a) the thickness through which the measurements are made is accurately measured, and (b) the source strength and detector are suitable for the distance over which the density is measured. The combination of source and detector that was used permitted defining soil density profiles. As a result of this study, it is recommended that the method described herein be used for nondestructive soil density measurements where the density beneath the surface of a sample must be known.

KEYWORDS: Gamma ray spectrometer; Nuclear methods; Soil density measuring devices

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PENETRATION RESISTANCE OF SOILS; Report 3, TESTS WITH CIRCULAR FOOTINGS IN COHESIVE SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 3 of series

5. AUTHOR(S) (First name, middle initial, last name)

Andrew J. Green

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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b. PROJECT NO. 4A061101A91D	Technical Report M-70-14, Report 3
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Assistant Secretary of the Army (R&D) Department of the Army Washington, D. C.

13. ABSTRACT

This report is the third in a series and concludes a study intended to establish scaling relations of forces and displacements for families of circular footings (plates and cylinders). The report contains the basic data and an analysis of the penetration results obtained from tests with circular plates and smooth-walled and rough-walled cylinders in a fat clay prepared at two strength levels. The footings ranged from 2.5 to 61 cm in diameter. In general, it was found that a dimensionless equation of the form $P/c = f(z/d)$, where P is pressure, c is soil cohesion, z is depth of penetration, and d is diameter of the footing, appears to be adequate for scaling forces and displacements. However, the data suggest that, in weak soils, there may be a minimum footing diameter below which the scaling law does not apply. A single dimensionless plot of the data obtained for the several sizes of footings is not supported by existing bearing capacity equations. The measured curves of penetration resistance (on the base of the footings) versus depth of penetration are in better agreement with those computed by the Meyerhof equation than with those computed from Brinch Hansen's equations.

KEYWORDS: Clays; Footings; Penetration resistance (Soils); Soil penetration tests

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
PERFORMANCE OF BOEING-GM WHEELS IN A LUNAR SOIL SIMULANT (BASALT)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Andrew J. Green
Klaus-Jurgen Melzer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES
Superseded by Technical Report M-71-10, Report 1

12. SPONSORING MILITARY ACTIVITY
George C. Marshall Space Flight Center
National Aeronautics and Space Administration, Huntsville, Alabama

13. ABSTRACT

Six versions of the Boeing-GM metal-elastic wheel were laboratory tested in a lunar soil simulant (crushed basalt that was processed to have a grain-size distribution approximately the same as that of samples collected during Apollo 11 and 12 flights) to determine their relative performance. The consistency of the soil was varied to cover a range of cohesive and frictional properties to simulate soil conditions assumed to exist on the moon. Programmed-slip and constant-slip tests were conducted with the U. S. Army Engineer Waterways Experiment Station single-wheel dynamometer system. Data indicated that the wheel covered with metal chevron tread over 50 percent of its contact surface may be slightly superior to other versions. Soil accumulated in the wheels during the tests, and the amount seemed to vary linearly with slip. Less soil accumulated in the 50 and 75 percent chevron-covered wheels than in the open-mesh one. Pull/load increased rapidly with slip to a near maximum at 15 to 25 percent slip for all wheels, then increased slowly to 100 percent slip. This suggests that the operation of a vehicle at slips higher than 25 percent for protracted periods invites immobilization, since a small increase in pull requirements as would occur if a soft soil spot or a steeper slope section were encountered suddenly, would probably induce 100 percent slip. Power requirements for all wheels also rose rapidly at slips beyond 15 to 25 percent. These observations reinforce the practical wisdom of using 20 percent slip as a datum from which to compare the performance of wheels (and vehicles).

KEYWORDS: Flexible wheels; Laboratory tests; Lunar roving vehicles; Lunar soils; Slip tests (Vehicles); Soil-wheel interaction; [Boeing-GM wheels]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE EVALUATION OF A FIRST-GENERATION ELASTIC LOOP MOBILITY SYSTEM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus-Jurgen Melzer
Andrew J. Green

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

Distribution limited to U. S. Government agencies only; proprietary information; May 1971. Other requests for this document must be referred to the National Aeronautics and Space Administration, Washington, D. C.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Advanced Development Office Advanced Manned Missions Program National Aeronautics and Space Administration Washington, D. C.

13. ABSTRACT

Programmed-slip tests were conducted on a lunar soil simulant to evaluate the performance of a first-generation Elastic Loop Mobility System (ELMS), developed by Lockheed Missiles and Space Company. The ELMS was tested with three types of surfaces on its outer face: (I) grousered with sandpaper strips glued between the grousers, (II) smooth with sandpaper strips glued on, and (III) grousered without sandpaper strips between the grousers. Soft-soil performance, and obstacle-surmounting, crevasse-crossing, and slope-climbing capabilities were investigated. Data indicated that the energy requirements and drawbar pull developed in soft soil decreased with increasing ELMS speed. The performance was not affected greatly by the various track surface conditions tested, but there were indications that a redesign of the track surface might improve the performance. The soft-soil mobility performance parameters for the ELMS are quantitatively comparable to the performance parameters of the Lunar Rover Vehicle wheel designed by Boeing Company and General Motors Corporation. The step obstacle-surmounting capability was dependent on the track surface conditions and the obstacle surfaces tested. The largest rigid, rough-surfaced obstacle climbed was 30 cm (12 in.) high, with the ELMS operating with track surface condition II, above. In contrast, the crevasse-crossing capability was independent of track surface condition and crevasse surfaces tested, the maximum crevasse traversed was 140 cm (4.6 ft) wide. The slope-climbing capability of the ELMS was dependent on the track surface condition and the manner in which the ELMS was linked to a two-wheeled trailer that simulated a second ELMS unit. The ELMS with track surface condition I, above, climbed the maximum slope, 30 deg, with the trailer mounted such that its attachment to the ELMS allowed free privoting. The maximum slope measured in slope-climbing tests was considerably higher than would have been predicted from the P_{20}/W value obtained in the level soil tests. However, there are certain indications that the slope-climbing capability of the ELMS can be predicted from tests on level ground.

KEYWORDS: Field tests; Lunar soils; Obstacles; Soil-track interaction; Tracked vehicles; Elastic Loop Mobility System

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

AN ANALYSIS OF GROUND MOBILITY MODELS (ANAMOB)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Adam A. Rula
Clifford J. Nuttall, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Weapon Systems Analysis Directorate Office of the Assistant Vice Chief of Staff U. S. Army Washington, D. C.

13. ABSTRACT

A study aimed at the analysis of existing ground models was initiated by WES and WNRE, Inc., under contract to WES. The objectives of the study were to analyze existing ground mobility models in order to: (a) determine their general level of usefulness and applicability to predicting cross-country performance of ground vehicles in the real world; (b) select the models that appear to be the more promising for this purpose and determine their usefulness and applicability in more definitive terms; (c) point out areas of the latter models in which additional research is needed; and (d) develop guidelines for future development of ground mobility models. Various Army sources and unclassified literature were canvassed for cross-country performance models that have been used or seriously proposed. Ten cross-country models were selected for detailed examination. The study produced a compendium of existing ground mobility submodels and comprehensive cross-country vehicle performance models that have been used or have a potential for future use. A structure for a NOW cross-country ground mobility model is suggested, along with some minor additions that do not require a great amount of effort. The study also presents a list of guidelines for the future development of ground mobility models along with plans for a future research program. This report consists of a main text containing an introduction, a presentation and analysis of single-feature models, a description and analysis of cross-country performance models, structure for a NOW comprehensive cross-country model, and guidelines and plans for future development of ground mobility models; and two appendixes that present in detail the soil-vehicle models (Appendix A) and stream-crossing models (Appendix B) examined for this study.
KEYWORDS: Military vehicles; Mobility; Mobility models; Performance predictions; State-of-the-art studies

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TRACK LOADS; Report 1, MODEL TRACK AND TEST PROGRAM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1967	86	27

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046, Trafficability and Mobility Research, Task -03, Mobility c. Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-71-5, Report 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 728 496

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

This introductory report reviews approaches taken by major investigators of the soil-track system and describes in detail the facilities, techniques, and long-range program that the U. S. Army Engineer Waterways Experiment Station will use to develop a comprehensive, quantitative description of the behavior of soils under track loads. The report also includes a comprehensive list of definitions of mobility terms applicable to the soil-track system. The laboratory model track to be used in the program is a fairly large-scale single-track system designed for use in a dynamometer carriage-soil bin arrangement. Initially, the model track will be used to determine the primary independent parameters for tracks operating in air-dry sand. A similar program of tests will be used to develop a means for predicting track performance in fine-grained soils. Tests to determine track performance in layered soil systems are also planned. In the final stages of the program, the data developed in the tests will be used to evaluate existing track performance theories and, if necessary, to develop a new theory. Field tests will then be conducted to determine to what extent laboratory developed track performance prediction terms must be modified to predict in-the-field performance. Appendix A describes the Plackett-Burman test design, which will be used to identify the most important variables of the system with a minimum of testing. Appendix B presents the Waterways Experiment Station mobility index formulas for tracked vehicles.

KEYWORDS: Glossaries; Laboratory tests; Soil-track interaction; State-of-the-art studies; Tracked vehicles; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

PERFORMANCE OF SOILS UNDER TRACK LOADS; Report 2, PREDICTION OF TRACK PULL PERFORMANCE IN A DESERT SAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-71-5, Report 2
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11. SUPPLEMENTARY NOTES Report was also submitted to Florida State University, Tallahassee, Fla., as thesis for Master of Science degree in Statistics	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A first-generation, quantitative description of straight-line track pull performance in a desert sand was sought by laboratory tests of a model track. Of 16 variables selected to provide a comprehensive description of the track-sand system, analysis of three Plackett-Burman (statistical) test designs showed four to merit initial study--soil strength G, track width b, track contact length ℓ, and load W. Principles of similitude were used to develop three dimensionless, independent terms--P_{20}/W, b/ℓ, and $G\ell^3/W$--to express the functional relation among these variables and P_{20} (pull at 20 percent slip, i.e. near-maximum pull). Data analysis demonstrated that the last two terms can be combined to $G(b\ell)^{3/2}/W$. A simple linear regression determined the least-squares fit of P_{20}/W to log $[G(b\ell)^{3/2}/W]$ as $P_{20}/W = 0.204482 + 0.161470 \log [G(b\ell)^{3/2}/W]$. Values of a_0 and a_1 in $P_{20}/W = a_0 + a_1 \log [G(b\ell)^{3/2}/W]$ were relatively stable in regression of data subgroups separated by the levels at which G, b, ℓ, and W were tested. Comparisons of linear regressions of form $P_{20}/W = a_0 + a_1 \log (Gb^{x_1}\ell^{x_2}/W)$ (with $x_1 + x_2 = 3.0$ and values of x_1 and x_2 varying from 0 to 3) also indicated the optimum prediction term to be $G(b\ell)^{3/2}/W$. Finally, the equation from a multiple linear regression of P_{20}/W on log G, log b, log ℓ, log W did not describe the test data significantly better than did the simple linear regression. From equation $P_{20}/W = a_0 + a_1 \log [G(b\ell)^{3/2}/W]$, expressions were obtained for P_{20}, W, and P_{20}/W in terms of a_0, a_1, k, and e, where $k = G(b\ell)^{3/2}$, for two performance levels of particular interest, the maximum-pull and zero-pull conditions.

KEYWORDS: Laboratory tests; Mathematical models; Mobility numbers; Performance predictions; Sands; Soil-track interaction; Track performance; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE PREDICTION OF THE SLOPE-CLIMBING CAPABILITY OF ELASTIC RIM WHEELS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (First name, middle initial, last name) Klaus W. Wiendieck	

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T061102B52A, Research in Military Aspects of Off-Road Mobility, c. Task 01, Military Aspects of Off-Road Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-71-6 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 731 205
10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A new semiempirical approach was attempted to predict the slope-climbing capability of wheels. This approach consisted of determining the pull performance of flexible wheels on yielding slopes by two extrapolations: one starting from the theoretically known pull performance of flexible wheels on unyielding slopes, and the other from experimentally determined performance of rigid wheels on yielding, level ground. The result is a prediction equation for the available pull of elastic-rim wheels (as a particularly simple case of pneumatic tires) on deformable, inclined soils in terms of soil deformability, cohesion, and internal friction; wheel flexibility and load; and slope angle. Various reduction factors developed to take sinkage and load effects into account were adjusted to satisfy known conditions and to make the two extrapolations compatible. By solving the prediction equation for zero pull, maximum slope-climbing capability can be determined; and by solving for zero slope, the maximum pull/load ratio on level ground can be obtained. Although the equation lacks theoretical rigor, it matches the extreme conditions on both ends of the soil and wheel deformability spectra and is thought to describe intermediate conditions with a high degree of confidence. The equation has been checked numerically only for the test conditions provided by elastic-rim wheels (Bendix lunar wheels) because they exhibited the simple deformation characteristics that were needed for this first formulation of a new approach. The more complex behavior of tires can be included in an extension of the study.

KEYWORDS: Flexible wheels; Slope performance; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EFFECT OF YAW ANGLE ON STEERING FORCES FOR THE LUNAR ROVING VEHICLE WHEEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Andrew J. Green

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. NASA Defense Purchase Request H-76596A d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-71--7 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD A006 518

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY National Aeronautics and Space Administration Washington, D. C.

13. ABSTRACT

A series of tests was conducted with a Lunar Roving Vehicle (LRV) wheel operating at yaw angles ranging from -5 to +90 deg. The load was varied from 42 to 82 lb (187 to 365 N), and the speed was varied from 3.5 to 10.0 ft/sec (1.07 to 3.05 m/sec). It was noted that speed had an effect on side thrust and rut depth. Side thrust, rut depth, and skid generally increased as the yaw angle increased. For the range of loads used, the effect of load on performance was not significant.

KEYWORDS: Lunar roving vehicles; Soil-wheel interaction; Steering; Wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE OF DUAL-WHEEL CONFIGURATIONS IN COARSE-GRAINED SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus-Jurgen Melzer

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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046-03 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-71-8 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 732 864

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT Three pneumatic tires were used in a laboratory study to compare the performance of dual wheels at zero spacing with the performance of single wheels and to determine the influence of tire spacing on dual-wheel performance. One-pass tests were conducted on air-dry, medium dense to very dense sand. The data were analyzed for powered wheels in terms of pull, torque, and sinkage coefficients and of efficiency, all at 20 percent slip, and for towed wheels in terms of towed force coefficients. The existing WES performance prediction system was used in both cases. Results showed that a powered dual wheel at zero spacing, considered as two wheels sharing equal load and exhibiting equal performance, outperformed a single wheel with the same characteristics as each wheel of the dual-wheel configuration. The performance of powered dual wheels decreased with increasing wheel spacing until the two wheels performed like single wheels. This critical spacing was reached when it became two to three and one-half times the width of one of the wheels. A dual wheel at zero spacing, considered as one wheel, performed practically the same as a single wheel with the same characteristics of the dual-wheel configuration; however, the dual wheel with zero spacing performed more efficiently than the single wheel over a certain range of load, deflection, and soil strength combinations. Little could be concluded from the analysis of the towed condition. Qualitatively, the towed force coefficient was larger for dual wheels than for a single wheel, its magnitude decreasing with increasing spacing until the towed force coefficient of the single wheel was reached.

KEYWORDS: Laboratory tests; Performance predictions; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance; Trafficability; Twin wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE OF BOEING LRV WHEELS IN A LUNAR SOIL SIMULANT; Report 1, EFFECT OF WHEEL DESIGN AND SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Andrew J. Green
Klaus-Jurgen Melzer

6. REPORT DATE December 1971	7a. TOTAL NO. OF PAGES 53	7b. NO. OF REFS 9

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-71-10, Report 1 (Supersedes Technical Report M-70-15) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 213

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY George C. Marshall Space Flight Center National Aeronautics and Space Administration Huntsville, Alabama

13. ABSTRACT

Six versions of the Boeing-GM wire-mesh wheel were laboratory tested in a lunar soil simulant, consisting of a crushed basalt with a grain-size distribution similar to that of samples collected during Apollo 11 and 12 flights, to determine their relative performance. The consistency of the soil was varied to cover a range of cohesive and frictional properties to simulate soil conditions assumed to exist on the moon. Programmed-slip and constant-slip tests were conducted with the U. S. Army Engineer Waterways Experiment Station single-wheel dynamometer system. The performance of the wheel covered with a metal chevron tread over 50 percent of its contact surface was slightly superior to that of other tread designs. The amount of soil accumulated in the wheels during the tests varied linearly with slip. Less soil accumulated in the 50 and 75 percent chevron-covered wheels than in the open-mesh one. Pull/load increased rapidly with increasing slip to a near maximum at 15 to 25% slip for all wheels, then increased slowly with increasing wheel slip to 100% slip. This behavior suggests that the operation of a vehicle at slips higher than 25% for protracted periods would result in immobilizing the vehicle, as would be the case if the vehicle were required to negotiate a soft soil spot or a steeper slope section. Specific power requirements for all wheels tested, as depicted by the power number, also rose rapidly at slips beyond 15 to 25%. These trends indicate that the wheel performance at 20% wheel slip provides a reasonable measure for comparing the limiting mobility performance capabilities of several versions of the basic GMC (wire-mesh) Lunar Roving Vehicle (LRV) wheel type. Following the selection of the Boeing-GMC wheel for LRV, additional wheel-soil interaction tests were conducted in the lunar soil simulant and are reported in Report 2 of this series. Appendix A describes in detail the WES dynamometer system in which the LRV wheel was tested.

KEYWORDS: Laboratory tests; Lunar roving vehicles; Lunar soils; Slip tests (Vehicles); Soil-wheel interaction; Wheels; [Boeing-GM wheels]

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1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE OF THE BOEING LRV WHEELS IN A LUNAR SOIL SIMULANT; Report 2, EFFECTS OF SPEED, WHEEL LOAD, AND SOIL

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Report 2 of a series

5. AUTHOR(S) *(First name, middle initial, last name)*

Klaus-Jurgen Melzer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY George C. Marshall Space Flight Center National Aeronautics and Space Administration, Huntsville, Alabama

13. ABSTRACT

Two nearly identical Boeing-GM wire-mesh Lunar Roving Vehicle (LRV) wheels were laboratory tested in a lunar soil simulant to determine the influence of wheel speed and acceleration, wheel load, presence of a fender, travel direction, and soil strength on the wheel performance. Constant-slip and three types of programmed-slip tests were conducted with the U. S. Army Engineer Waterways Experiment Station single-wheel dynamometer system. Test results indicated that performance of single LRV wheels in terms of pull coefficient, power number, and efficiency were not influenced by wheel speed and acceleration, travel direction, the presence of a fender, or wheel load. Of these variables, only load influenced sinkage, which increased with increasing load. For a given slip, the pull coefficient and power number increased with increasing soil strength. However, for a given pull coefficient or slope, slip was less in firmer soil; thus, the power number decreased and efficiency increased with increasing soil strength.

KEYWORDS: Laboratory tests; Lunar roving vehicles; Lunar soils; Slip tests (Vehicles); Soil-wheel interaction; Wheels; [Boeing-GM wheels]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STUDIES OF THE DYNAMICS OF TRACKED VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report

5. AUTHOR(S) (First name, middle initial, last name)

Allan S. Lessem, Newell R. Murphy, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c. Task 01	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A field test program was conducted with four tracked vehicles to determine how strongly the presence of the track affects ride dynamics and to guide in the development of a mathematical model. The vehicles were towed over an assortment of obstacles, first with tracks installed and then with tracks removed. A direct comparison of dynamic responses under these two conditions indicated that the influence of the track is strongly dependent on velocity, and that mathematical models of tracked vehicles must incorporate a track contribution. A mathematical model that portrays essential features of track mechanics without excessive detail was developed.

KEYWORDS: Field tests; Mathematical models; Obstacles; Ride dynamics; Tracked vehicles

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Tank-Automotive Command, Warren, Mich. U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

VEHICLE MOBILITY ASSESSMENT FOR PROJECT WHEELS STUDY GROUP

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Adam A. Rula
Clifford J. Nuttall, Jr.
Howard J. Dugoff

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-73-1
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Department of the Army WHEELS Study Group and Directorate of Research, Development and Engineering, U. S. Army Materiel Command

13. ABSTRACT

Project WHEELS is a study to evaluate the performance of individual standard military trucks both off and on road in relation to their missions and the cash savings possible through the elimination of special military automotive features, such as front-wheel drive, or the use of commercial vehicles in some missions. Such evaluations can only be based upon the most reliable assessments of mobility performance possible. The AMC-71 Ground Mobility Model was used to assess the off- and on-road speed performance of a group of military and commercial vehicles and vehicles with trailers or howitzers, totaling 48 cases of direct interest and 6 reference vehicles, ranging from 1-ton gross vehicle weight to 90-ton gross combined weight. The terrain data used in predicting off-road performance were obtained from transects, or strips of ground, about 3 by 52 km located in West Germany, Thailand, and Arizona, each representative of different types of climatic zones and terrain conditions. The road data used in predicting on-road performance were collected from segments of primary, secondary, and trail-type roads; each segment was approximately 100 miles long. Both off- and on-road performance was predicted in terms of speed for all vehicles and vehicle-trailer or -howitzer combinations included in the study. Off-road speed was predicted for traverses made up of five straight lines equally spaced along the length of the transects. On-road speed was predicted for the total length sampled in each road category. Several off-road terrain traverse speed predictions were made. These included speed made over a combination of areal (patches of homogeneous terrain) and linear (streams and rivers) terrains identified as V_{110}, speed over areal terrain (V_{100}), and speed over areal terrain with the worst 10 percent removed from consideration (V_{90}). On-road speed predictions were made for trails (V_3), secondary roads (V_2), and primary roads (V_1). Performance in terms of percentage of off- and on-road areal terrains in the traverses and trails, respectively, that the vehicles could not traverse is also indicated. Rankings of the performance of the vehicles considered were made on the basis of the V_{90} and V_3 speeds for each transect or road network.

KEYWORDS: Military vehicles; Mobility models; Off-road mobility; On-road mobility; Performance predictions

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
A NUMERICAL MODEL OF THE RIDE DYNAMICS OF A VEHICLE USING A SEGMENTED TIRE CONCEPT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Windell F. Ingram

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T162112A046, Task 03	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report M-73-5
c. d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 913 281L

10. DISTRIBUTION STATEMENT
Distribution limited to U. S. Government agencies only; computer program documentation; August 1973. Other requests for this document must be referred to U. S. Army Engineer Waterways Experiment Station (WESFV).

11. SUPPLEMENTARY NOTES Report was also submitted to Mississippi State University, State College, Mississippi, as thesis for degree of Master of Science, Engineering Mechanics, College of Engineering.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Research, Development and Engineering Directorate, Washington, D. C.

13. ABSTRACT
The purpose of this study was to develop and validate a digital computer simulation of the ride dynamics, including bounce, pitch, and roll, of a general single-hull, solid-axle vehicle with an arbitrary number of axles. The study also included an effort to minimize the execution time and thus the cost of the simulation by providing automatic determination of the optimum numerical integration interval to be used at each point in the simulation. The numerical integration method used was the Runge-Kutta-Merson method, which is a fourth-order method. The method requires five derivative evaluations per integration and provides an estimate of the truncation error that can be used for automatic interval adjustment. Field tests of a representative vehicle traversing a single obstacle at three different speeds and a cross-country terrain at one speed were simulated. Graphs are presented comparing simulated vehicle responses, with field test data provided by the Waterways Experiment Station. The effects of integration step-size on simulated vehicle responses are illustrated with graphs comparing simulated vehicle responses using several different integration intervals. A discussion of criteria for automatic management of the integration interval is presented.

KEYWORDS: Computerized simulation; Flexible wheels; Ride dynamics; Vehicle dynamics

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U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	Unclassified
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3. REPORT TITLE

VEHICLE/ROAD COMPATIBILITY ANALYSIS AND MODIFICATION SYSTEMS (VRCAMS)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Victor C. Barber
Newell R. Murphy

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Office, Chief of Engineers, U. S. Army Washington, D. C.

13. ABSTRACT

The Vehicle/Road Compatibility Analysis and Modification System (VRCAMS) brings together the appropriate disciplines pertinent to vehicles, mobility, road geometrics, structures and maintenance to determine and measure the compatibility of vehicle and its environment and the resultant product of movement. The system also treats the effects of constructive or destructive modification of vehicle and/or environment and the resultant impact on vehicle movement. The first-generation system, in computer code, serves to successfully combine all known parameters affecting vehicle movement, thereby taking total advantage of the state-of-the-art in related disciplines. Foreseeable and programmed improvements to the system imply significant advances in the state-of-the-arts of road deterioration analysis, vehicle reliability analysis, vehicle-road optimization, and overall allied material optimization. The VRCAMS consists of several subsystems that respectively treat mobility and ride dynamics, traffic volume, structural characteristics, maintenance, and vehicle movement. The parameters in each of the subsystems are brought together in a comprehensive manner to provide output data pertinent to vehicles moving on roads. Outputs provided by the VRCAMS include speed of given vehicles on specific road segments, traffic volumes that road segments can sustain at various levels of service, structural life of a specific road segment subject to known quantities of traffic, maintenance requirements to extend road segment life, and delivery rate and travel time for vehicles on road segments. Refinements and additions to the current model will provide for a greater degree of accuracy and for a broader range of applications such as road and vehicle design optimization, optimum use of roads and vehicles, and improved logistical and tactical planning.

KEYWORDS: Mobility models; Road capability models

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

HELICOPTER MOVEMENT ON UNIMPROVED TERRAIN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Edgar S. Rush
Charles E. Green

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Aviation Systems Command St. Louis, Missouri

13. ABSTRACT

A brief review is presented of the current state of the art of criteria for determining the ground-flotation requirements for landing gear of aircraft, particularly fixed-wing aircraft, and criteria for estimating cross-country performance of military vehicles. Discussions are also presented of three soil strength parameters: California Bearing Ratio (CBR), airfield index (AI), and cone index (CI). Results of tests with three helicopter tires in prepared and natural soils are presented, and relations are shown among soil strength, towed motion resistance of some assumed helicopter configurations, and maximum-drawbar-pull capabilities of selected ground vehicles. Also presented is the distribution of terrain factors mapped in a selected West German transect and the probability of moving helicopters over the terrain. No single soil strength measuring system is completely adequate for characterizing soil conditions for the purpose of estimating performance of all aircraft and all ground vehicles in all operating situations. The CBR system appears to be adequate for prepared surfaces and unprepared surfaces with CBR above about 2.5 when estimating the ground-flotation requirements of aircraft and relating the requirements to the design capabilities of airfields according to established criteria. The CI system has been used successfully for characterizing soil strength for the purpose of estimating performance of ground vehicles on unimproved terrain. Limited testing reported herein indicates that the CI system can be used successfully for estimating the soil strength requirements for movement of helicopters over unimproved terrain; therefore, a procedure can be established wherein design requirements for helicopter landing gear can be made.

KEYWORDS: Aircraft tires; Ground flotation; Helicopter landing zones; Helicopters; Soil strength; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A VARIABLE-STRESS VEHICLE RELIABILITY MODEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Allan S. Lessem

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Assistant Secretary of the Army Research, Development, and Engineering Directorate, Washington, D. C.

13. ABSTRACT

A mathematical model bearing on aspects of reliability and maintenance of ground vehicles is described in this report. The structure and computational attributes of the model are complementary to those of the AMC-71 Ground Mobility Model. The principal product of the vehicle reliability model is a probability statement such as the following: "The probability of no failure of an M60 tank having an accumulated mileage of 174 miles and a maintenance history of immediate replacement of failures is 74 percent during traversal of 25 miles of terrain having stresses whose cumulative effect is 35 percent in excess of standard stresses." Statements of this nature are made for a given vehicle traversing terrain of given attributes. Pertinent data are obtained directly from AMC-71. Probability data are required in the form of probability density functions for the vehicle components obtained under conditions of reliability stresses previously identified as standard. Other outputs are expected numbers of component and vehicle failures, effective vehicle mean time between failures, and inherent availability. Problems of data acquisition are discussed. Two aspects of the model are speculative in that direct data sources are not presently available: (a) specification of and testing at conditions of terrain regarded as imparting standard stresses to reliability and (b) characterizing changes in reliability due to departures of stresses from their standard values. Several examples are presented, including one that uses data gathered during an intensive reliability demonstration program for the XM705 vehicles.

KEYWORDS: Maintenance; Mathematical models; Military vehicles; Mobility models; Reliability

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U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	Unclassified
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3. REPORT TITLE

PERFORMANCE EVALUATION OF A SECOND-GENERATION ELASTIC LOOP MOBILITY SYSTEM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus-Jergen Melzer
G. D. Swanson

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	George C. Marshall Space Flight Center National Aeronautics and Space Administration Huntsville, Alabama

13. ABSTRACT

Tests were conducted to evaluate the mobility performance of a second-generation Elastic Loop Mobility System (ELMS II) developed by Lockheed Missiles and Space Company for the National Aeronautics and Space Administration (NASA). Performance on level test lanes and slopes of lunar soil simulant (LSS) and obstacle-surmounting and crevasse-crossing capabilities were investigated. In addition, internal losses and contact pressure distributions were evaluated. To evaluate the soft-soil performance, two basic soil conditions were tested: loose (LSS_1) and dense (LSS_5). These conditions embrace the spectrum of soil strengths tested during recent studies for NASA related to the mobility performance of the LRV. Data indicated that for the tested range of the various performance parameters, performance was independent of unit load (contact pressure) and ELMS II drum angular velocity, but was influenced by soil strength and ELMS pitch mode. Power requirements were smaller at a given system output for dense soil than for loose soil. The total system output in terms of pull developed or slope-climbing capability was larger for the ELMS II operating in restrained-pitch mode than in free-pitch mode. The angle of the maximum slope that the ELMS II climbed in free-pitch mode on dense soil was 35 deg; on the same soil, but with the system operating in restrained-pitch mode, the angle of the maximum climbable slope was 34 deg, and on loose soil, it was 27 deg. The smaller maximum slope angles for restrained-pitch mode resulted from load being transferred from the ELMS II to the trailer, which was used during the slope tests to stabilize the single unit. If this load transfer can be overcome, for example by replacing the trailer with a second powered unit, this two-unit ELMS should be able to climb slopes with angles up to 38 deg on dense soil and up to about 35 deg on loose soil. The slope-climbing capability can be estimated from results of tests conducted on level ground. The maximum rigid-step obstacle surmounted was 46 cm high, and the maximum crevasse crossed was 100 cm wide. It can be assumed from the ELMS performance during these tests that obstacles and crevasses with larger dimensions could be negotiated if the trailer were replaced by a second powered ELMS II unit with a pitch-control system in the linkage between the units. Internal losses were smaller than those of the first-generation ELMS for torques up to about 60 percent of the total available torque; for higher torques, the reverse was the case. The contact pressure distribution along the longitudinal axis of the loop showed maximum contact pressure occurring toward the middle of the loop, whereas the transverse cross-sectional distribution showed pressure concentrations at the loop edges. The ELMS II showed an overall superior performance as compared with that of the first-generation ELMS and the wheels used on the U. S. Lunar Roving Vehicles.

KEYWORDS: Elastic loop mobility system; Lunar roving vehicles; Lunar soils; Mobility; Wheels

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer applications	Soil-wheel interaction
Rigid wheels	Stresses under wheels
Shear properties	Vehicle mobility
Soil stresses	Wheels

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The problem of vehicle mobility is a complex one in that a rigorous analytical treatment of the mechanics involved between vehicle characteristics, such as geometry, size, and driving forces, and the properties and responses of soil that supports a moving vehicle has not been developed. In general, immobilization problems occur as a result of the loss of or excessive demand for traction created by a combination of sinkage, slope, forces applied, obstacles, and environmental conditions. Immobilization problems associated

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20. ABSTRACT (Continued)

with poor traction due to weak soils or slippery surfaces are not limited to rigid or pneumatic-tired wheels, but also affect powered track wheels with grousers. Two approaches have been followed in attempting to solve the soil-wheel interaction problem: an analytical approach based on the elastic solution of a plane strain problem, and an experimental approach based on the relationship between the shear and normal stresses that may occur within the vicinity of or at the interface of the soil and the wheel of a moving vehicle. The analytical solution is based on the assumption that the stresses within the soil are the results of the tangential and radial stresses created by a wheel partially embedded in soil with an impending rotation. The Airy stress function was used in representing the stresses within the soil in terms of analytic functions. The Schwarz-Christoffel equation was used to transform the geometry and the boundary condition of the region beneath the wheel and to match them with the stress functions. The Cauchy integral equation was applied on the transformed boundary conditions to obtain the shear and normal stress at any point within the region of the soil-wheel system. A computer program for reducing the results and obtaining numerical values of the stresses at any point within the vicinity of the wheel was also written. It is believed that the analytical solution developed will permit the evaluation of stresses within the soil beneath a wheel that result from various combinations of radial and tangential stresses. The experimental investigation was designed to investigate the shear stresses and traction forces that may exist between a model rigid wheel or tire wheel and the supporting soil. CH material (Vicksburg buckshot clay) was compacted and tested in an annular torsion shear machine. Four types of specimens were tested in this study: the first series of tests consisted of shearing homogeneous soil specimens; in the second series, the soil was sheared against smooth rubber; in the third series, the soil was sheared against polished stainless steel; and in the fourth series, a nonhomogeneous soil specimen, with upper and lower halves having different water contents, was sheared. The initial normal stresses used in the test program were 5, 15, and 30 psi, and all specimens were sheared under constant-volume conditions at rates of shear deformations of 0.002, 0.2, and 2.0 in./min. Test results showed that nonhomogeneous soil specimens with upper and lower halves having water contents of 26 and 16 percent, respectively, were stronger than homogenous soil specimens with a uniform water content of 26 percent and that the strengths of both types of soil specimens were higher than those at the interface of smooth rubber or polished stainless steel and soil. Test results showed that the strength of nonhomogeneous soil specimens was higher than that of homogeneous soil specimens with uniform water content, and the strengths of both types of soil specimens were higher than those at the interface of smooth rubber or polished stainless steel on soil. The results also showed that the shear resistance developed between soil and rubber is much higher than that developed between soil and polished steel. The shear stress at failure for all test series showed an increase with increasing initial normal stress and increasing rate of shear deformation. The shear stresses at the interfaces of smooth rubber and soil and also of polished steel and soil dropped sharply when the plane of contact was covered with a film of water. The peak shear stress obtained from each test series was plotted as a function of the corresponding normal stress in order to facilitate its use in analytical solutions.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Technical Report M-75-1	2. GOVT ACCESSION NO. AD A013 491	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SMALL-SCALE MOBILITY TESTS IN FINE-GRAINED LAYERED SOILS		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Gary D. Swanson Thomas R. Patin		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project 1T161102B52A Task 01, Work Unit 6
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Materiel Command 5001 Eisenhower Avenue Alexandria, Va. 22333		12. REPORT DATE June 1975 13. NUMBER OF PAGES 74
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fine grained soils	Soil stratification
Laboratory tests	Soil strength
Mobility tests	Soil-wheel interaction
Scale models	Tire tests

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Laboratory single-wheel tests were conducted with a 2.50-4 tire on uniform fine-grained soil and on two conditions of thick-layered, fine-grained soils: condition I in which a soft layer was placed over a firm layer, and condition II in which a firm layer was placed over a soft one. In both cases, the smallest ratio of layer thickness to tire width tested was 0.33. The results of the baseline tests on uniform soil showed that the WES numeric prediction system, which had not hitherto been used for such a small tire, (Continued)

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

will predict the performance of the small tire as accurately as it predicts the performance of a large tire. The system also can be used in predictions for layered-soil systems, if the soil strength of the top layer is used in the numeric and as long as the lower layer is relatively strong in relation to tire loading. When the soft upper layer becomes thin, the primary phenomenon is lubrication of the firm lower layer by the soft upper layer, and a different mechanism is involved. When a relatively thick soft layer overlies a hard one, the change in pull performance increases as tire deflection is decreased for a given top-layer thickness and wheel load. As values of the clay mobility number increase, the critical thickness of the top soil layer decreases and the change in pull performance decreases. Torque performance does not change with the ratio of top-layer thickness to tire section width. When a hard layer overlies a soft one, pull and torque performance show slight tendencies to decrease with thickness of the top layer. Torque requirements increase when the tire breaks through the hard layer into the underlying soft layer. Generally, it is suggested that efforts be directed toward investigations of thin-layered soil systems instead of pursuing further the problem of thick-layered soil systems.

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE REPORT ON
TRAFFICABILITY CONDITIONS AND AIRFIELD SITE SELECTION IN AN AREA IN NORFOLK COUNTY, EAST ANGLIA, ENGLAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report.

5. AUTHOR(S) (Last name, first name, initial)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b NO. OF REFS
November 1952	51	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-01 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-19 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

This study was performed as an outgrowth of the interest expressed by the British War Office in the apparent progress made by the United States in identifying soils from aerial photography. It was a joint undertaking performed by personnel from Purdue University and WES. Two separate tests were performed: one, simulating emergency operation conditions, was completed in a 72-hour period; the other, simulating routine intelligence production, was completed within a six-week pe[illegible]. The following finished products were furnished: (1) necessary explanatory text and legends; (2) an overlay showing cross-country movement conditions based on evaluatic of soils, relief, vegetation, obstacles, and seasonal variations; (3) an overlay showing areas suitable for airfields, based on soils, relief, drainage, obstacles, and availability of construction materials; (4) an overlay showing extent of photo coverage and indication of quality of photography; and (5) a statement giving the team composition and number of man-hours required for the production and reproduction stages of the test results.

KEYWORDS: Airfield site selection; Airphoto interpretation; Trafficability; Trafficability mapping; [England] ·

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Security Classification

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)

U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

A STUDY OF MOISTURE-CONTENT DETERMINATIONS ON SELECTED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1954	7	

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

Miscellaneous Paper No. 4-73

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

AD 041 085

10. DISTRIBUTION STATEMENT

Approved for public release: distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Office of the Chief of Engineers,
Airfields Branch, Engineering Division,
Military Construction

13. ABSTRACT

Report describes the tests performed and the results of the investigation, together with a suggested laboratory procedure for determining reliable moisture-content values on those soils that give erratic values in the standard laboratory moisture-content test.

KEYWORDS: Soil moisture; Soil tests (Laboratory); Water content determination (Soils)

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY SURVEY OF SELECTED AREAS, CAMP STEWART, GEORGIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1954	20	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-001 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-101 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A 10-day survey was made by a team of geologists, engineers, and engineering aides. Trafficability maps of the selected area were then prepared at a scale of 1:25,000. The analysis described and presented graphically on the maps is concerned solely with the ability of M48 tanks (or vehicles of equivalent characteristics) to operate off roads on natural soil surfaces in the area surveyed. The analysis does not consider the use of special vehicles or improvements of the natural soil surfaces by construction methods.

KEYWORDS: Military bases; Mobility; Tanks (Combat vehicles); Trafficability maps; [Camp Stewart, Ga.; M48 tank]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

FIELD TESTS OF NUCLEAR INSTRUMENTS FOR THE MEASUREMENT OF SOIL MOISTURE AND DENSITY

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Rush, E. S.
Reinhart, K. G.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
March 1955	26	8

8a CONTRACT OR GRANT NO b PROJECT NO 8-07-05-001, Trafficability of Soils as Related to the Mobility of Military Vehicles c d	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-117 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 073 388

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
This study was conducted by the USDA Forest Service.	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

This paper presents the results of field testing of nuclear instruments for the purpose of determining if such instruments could be substituted for instruments now in use by the Forest Service to expedite collection of soil moisture and density data in a study being conducted for the Waterways Experiment Station. Additional tests of nuclear instruments are being conducted by the Waterways Experiment Station and Ohio River Division laboratories, Corps of Engineers, in conjunction with airfield construction. This report, therefore, is to be considered an interim report since future data may warrant revisions of its contents.

KEYWORDS: Field tests; Nuclear equipment; Nuclear methods

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT; REPORT ON THE FAIRBANKS, ALASKA, EXTENSION

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Tobiaski, R. A.
Larson, D. E.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO. OF REFS
July 1955	154	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-001 c. Project Title: Trafficability of Soils as Related to the Mobility of Military Vehicles	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-135 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 747 826

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
U. S. Forest Service cooperated in this study.	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The U. S. Forest Service, in cooperation with the Waterways Experiment Station, developed methods of predicting soil moisture in the Vicksburg Area. To develop methods for other soil types under a variety of climatic conditions, extension studies were established. This report contains the results of the Fairbanks, Alaska, extension study. Climatic, soil-moisture, and permafrost records were obtained for the period May through September 1954. Field and office procedures used were similar to those previously reported in Technical Memorandum No. 3-331, Report No. 3.

KEYWORDS: Climatological data; Soil data; Soil moisture prediction; Subarctic regions; Trafficability prediction; [Alaska]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
VEHICLE MOBILITY ON SOFT SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Foster, C. R.
Knight, S J.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
January 1956	11	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-001 c. Project Title: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-147 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 841 344

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Published in The Military Engineer, Vol.49, No.328, pp.92-94, March-April 1957.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The engineering sciences of aerodynamics and hydrodynamics have served aircraft design and ship design well. A comparable basis for the design of land-borne vehicles must be evolved. Hope lies in soil mechanics; but in the past this has been concerned with stability and elasticity problems primarily in connection with static loads. While the research so far will serve as an excellent foundation, a new perspective--treating of dynamic loads on materials in a plastic state--must be evolved. This paper discusses research being conducted at the Waterways Experiment Station along these new lines.

KEYWORDS: Dynamic loads; Mobility; Soft soils, State-of-the-art studies

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STRESSES UNDER MOVING VEHICLES; A PILOT STUDY OF WES EARTH PRESSURE CELL ACTION IN COMPARATIVELY SOFT SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (Last name, first name, initial)

Thompson, A. B.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1957	30	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-100, Mobility of the Army c. Subproject: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-230 Report No. 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 841 345

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Subsequent reports in this series are designated Technical Report No. 3-545.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A pilot study to determine the suitability of the WES earth pressure cell to measure stresses under stationary and moving (driven) pneumatic tires in fairly soft soil showed the WES cell to have the same utility it had been found to have in previous studies of stresses induced by static loads in firmer soils. Additional experience in testing procedures was gained which may be applied to more complete studies in the future. Interesting comparisons were made of the effects of tire pressure, speed, and repetition of load on stresses induced at various depths in the soil, and of measured and computed stresses.

KEYWORDS: Pneumatic tires; Pressure cells (Soils); Soft soils; Stress distribution; Stresses under wheels

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STATISTICAL OCCURRENCE OF SOIL STRENGTH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
November 1957	6	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-100 •Project Title: Mobility of the Army d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-238 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Published in The Military Engineer, Vol.52, No.346, March-April 1960, Titled "Soil Strength Study."	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The ability of a soil to support the movement of a military vehicle--its trafficability--can be quantified in terms of rating cone index, a parameter that recognizes not only the strength of a soil in situ but also the strength it will attain under a moving vehicle. The principal influence on the rating cone index of a soil, especially a fine-grained soil, is the amount of water it contains. Waterways Experiment Station studies have shown that in a humid climate the top 12 in. or so of a given fine-grained soil attains a certain maximum soil moisture early in the wet season and maintains this moisture with very little deviation throughout this season. The field maximum offers a practical moisture datum for evaluating the trafficability of verious soils. In this report, the distribution of the rating cone index values measured in the 6- to 12-in. layer at 681 sites is summerized. A frequency curve of these date can be used to ascertain the percentage of areas tested that had rating cone indexes below a certain value. By spotting the rating cone index requirement for a given vehicle, the curve also may be used to determine the percentage of area trafficable by the vehicle.

KEYWORDS: Rating cone index; Soil strength; Statistical distributions

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b GROUP

3. REPORT TITLE
VEHICLE MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
October 1957	15	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 8-70-05-100, Mobility of the Army	Miscellaneous Paper No. 4-241
c. Subproject: Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 841 346

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at meeting of Hawaiian Sugar Technologists, Honolulu, Hawaii, 11-14 November 1957.	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This paper presents the status of the trafficability-mobility studies and their application in the solution of transportation problems facing contractors, loggers, miners, and agricultural plantation managers.

KEYWORDS: Mobility; State-of-the-art studies; Trafficability

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

COMPARISON OF PERFORMANCE CHARACTERISTICS IN SNOW OF THE POLECAT AND WEASEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1958	16	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 8-70-05-100, Mobility of the Army	Miscellaneous Paper No. 2-282
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The polecat, an articulated vehicle, was compared with the weasel in several tests on snow ranging from 1-1/2 to 4 ft deep. Results showed that the polecat created slightly deeper ruts, but snow strength and density in the ruts were about the same for both vehicles. The depth to which stresses were induced below the rut surface was slightly less for the polecat. The polecat exerted more drawbar pull in towing and required less when being towed. The polecat exerted more drawbar pull in towing and requires less when being towed. The polecat excelled in comfort and maneuverability. Additional tests in highly remoldable soils are recommended.

KEYWORDS: Articulated vehicles; Field tests; Military vehicles; Mobility; Snow trafficability; Tracked vehicles; [Polecat; Weasel]

Unclassified

Security Classification

M,E

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A LIMITED STUDY OF FACTORS THAT AFFECT SOIL STRENGTH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1958	34	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-05-100, Mobility of the Army c. Subproject 8-70-05-101, Trafficability of Soils as Related to the d. Mobility of Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-284 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

To obtain an approximate measure of the gross effects of various natural influences on the strength of a soil, its strength under natural conditions was compared to its strength under similar laboratory conditions of moisture content and density. The test area was located on a lake shore where the soil was very uniform in type and decreased in moisture content with distance from the lake, giving a wide range of moisture and strength conditions. The soil, a heavy clay, was tested for moisture, density, and cone index in its natural state and in the laboratory, and for remolding index in the field. Principal conclusions were that (a) the cone index of a given sample at a given moisture content and density varies with the structure and compaction history of the sample, and (b) compaction effort, difference in water-holding capacity of the soil in situ and after laboratory treatment, and surcharge are the principal factors affecting laboratory density-strength-moisture content relationships.

KEYWORDS: Clays; Field tests; Fine grained soils; Soil density; Soil moisture; Soil property relations; Soil strength; Trafficability
Laboratory tests

DD FORM 1473 Unclassified

Unclassified

Security Classification

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

METEOROLOGICAL AND TRAFFICABILITY DATA, U.S.-CANADIAN ARCTIC WEATHER STATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Rush E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO OF REFS
January 1959	33	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-00-000 Ground Mobility Research c Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility d Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-298 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 305

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This report presents soil and meteorological data collected during the summer months (June, July, and August) of 1955 at the Arctic weather stations located at Alert and Mould Bay, and during June-September 1954, 1955, and 1956 at Eureka. At each weather station, three test sites were established--one at a low elevation one at an intermediate elevation, and one at a high elevation. Cone index, moisture content, density, depth to permafrost, and meteorological data were recorded. The data were not sufficient to determine relations between soil moisture and meteorological parameters, but did permit an approximate evaluation of trafficability conditions at the three sites during the summer season.

KEYWORDS: Arctic regions; Field tests; Meterological data; Soil property relations; Trafficability, Trafficability data; [Canada; Northwest Territory]

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Unclassified

Unclassified

Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

AERIAL PENETROMETER DEMONSTRATION AT FORT RUCKER, ALABAMA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1959	21	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-00-000 Ground Mobility Research c. Subproject 8-70-05-400, Trafficability of Soils as Related to the d. Mobility of Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-300 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 625 601

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A demonstration of the performance of the aerial penetrometer in several soil conditions was given at Fort Rucker, Alabama, by the Air Force Cambridge Research Center and was attended by representatives of WES with the objective of obtaining data that might widen the knowledge of soil property-aerial penetrometer relations. This report presents the soil and penetrometer-performance data collected, and compares the relations developed from these data with similar ones developed for other soils (see Technical Report No. 3-462, Reports 1, 2, and 3).

KEYWORDS: Aerial cone penetrometers; Field tests; Military bases; Soil strength relations; [Fort Rucker, Ala.]

DD FORM 1 JAN 64 1473

Unclassified

Unclassified

Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

A LIMITED STUDY OF SNAP-TRACS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1959	19	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-322
b. PROJECT NO 8-70-00-000 Ground Mobility Research •Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 291

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C.

13. ABSTRACT

A limited test program was conducted to compare the performances of the M135 and M211 2-1/2-ton military cargo trucks while operating with and without snap-tracs on a silty, wet soil. The vehicles gave limited performance while operating without the traction device, but greatly improved performance when they were equipped with snap-tracs. It was concluded that the use of snap-tracs did not improve their traction characteristics in an extremely wet, soft, slippery soil. However, it was not possible to determine positively whether the C-shaped members of the snap-tracs "open" and act like grousers under the wheel. Additional tests are recommended to compare the performance of the unmodified snap-tracs with the performance of snap-tracs with the C-shaped member locked in place and with the C-shaped member removed.

KEYWORDS: Cargo vehicles; Field tests; Military vehicles; Mobility; Soil-track interaction; Traction devices; Trafficability; [M135 cargo truck; M211 cargo truck]

13

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

EFFECT OF MOLD SIZE AND OTHER FACTORS ON LABORATORY CONE INDEX MEASUREMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Green, A. J.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1959	27	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Miscellaneous Paper No. 4-327
c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility d. of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 841 347

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A brief study was made to determine the effect of mold size on cone index. Three fine-grained soils (two silts and one heavy clay), with cone indexes ranging from 20 to 250, were tested in molds ranging from 1.9 to 15.5 in. in diameter. The variables, other than mold size, were maintained as near constant as practicable and did not significantly affect the cone index values recorded. Results showed that for a given soil at a given moisture content and density, decreasing the size of the mold had no effect on cone index until a certain minimum diameter was reached; use of molds below this minimum size resulted in considerably higher cone index values than would have been determined on the same soil in larger molds. An average curve of minimum mold diameter versus cone index was established. Use of mold sizes equal to or above this curve should produce cone indexes that are relatively free of the confining effects of the mold. It is recommended that this average curve be used as a guide in the selection of minimum mold diameters for laboratory investigations of the strength of fine-grained soils.

KEYWORDS: Cone index; Laboratory equipment; Laboratory tests; Soil strength; Soil strength test instruments; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PREDICTION OF SOIL MOISTURE FROM SOIL AND WEATHER RECORDS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Burke, H. D.
Turnbull, W. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 1959	11	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Subproject No. 8-70-05-400, Trafficability of Soils as Related to d. Mobility of Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-338 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD A0C) 496

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Presented at Int Assn of Hydrology Symposium on Forests and Waters, Kassel, Germany, 8-11 September 1959, Public. No.48 de A.I.H.S.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

As part of a study to develop means of estimating the ability of soils to permit vehicular traffic, a method was developed for predicting the moisture content of soils. This paper summarizes the relations found necessary for the prediction of moisture in the surface foot of soil and discusses the accuracy with which these predictions have been made.

KEYWORDS: Meteorological data; Soil moisture prediction; Soil property relations; State-of-the-art studies

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
PILOT STUDY TO EVALUATE THE SQUEEZE TEST FOR USE IN VEHICLE-MOBILITY RESEARCH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Green, A. J., Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1959	26	9

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility d. of Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-350 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 841 348

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The Jurgenson squeeze test was studied to evaluate the possibility of using it as an aid in understanding the strength-deformation properties of soils in vehicle-mobility research. The squeeze test was easy to perform and did not require expensive equipment. Its results correlated well with the results of the other strength tests including cone penetrometer measurements. Results of this study support the theory that the squeeze test determines the average strength of the soil, whereas the triaxial test measures the strength along the weakest plane. The squeeze test is considered suitable for initial inclusion in laboratory vehicle-mobility research programs.

KEYWORDS: Laboratory tests; Soil strength; Soil strength test instruments; Trafficability

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS;FOUR SOILS IN THE PANAMA CANAL ZONE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 1 in a series.

5. AUTHOR(S) (Last name, first name, initial)
Pula, A. A.
Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1959	65	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of Military Vehicles	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355 Report 1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD A006 520

10. AVAILABILITY/LIMITATION NOTICES
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Four sites in the Canal Zone were studied to determine whether the techniques used to develop a soil moisture prediction system for temperate-climate soils could be successfully applied to tropical-climate soils. Soil moisture and strength data were collected weekly at the sites, and climatological data daily, for 18 months. Actual soil-moisture contents on the starting date were used to start the predictions. Comparison of predicted and measured soil moistures indicate that: (a) the techniques used to develop a soil-moisture prediction system for temperate climate could be successfully applied to tropical soils: (b) the average soil-moisture predictions developed from temperate climate data can be used with some success on tropical soils; (c) the quality of moisture content-strength relations for tropical soils is considerably lower than similar relations derived for temperate-climate soils. Conclusions regarding trafficability of the region during the wet season were: (a) upland soils are generally trafficable though wheeled vehicles may fail to climb slopes because of slipperiness; (b) lowland soils are generally trafficable only for low-ground-pressure tracked vehicles.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Panama Canal Zone]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PUERTO RICO STUDY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 in a series

5. AUTHOR(S) (Last name, first name, initial)

Tobiaski, R. A.
Bassett, J. R.
Rush, E. S.

6. REPORT DATE February 1960	7a. TOTAL NO. OF PAGES 116	7b NO. OF REFS 19
8a CONTRACT OR GRANT NO. b. PROJECT NO. 8-70-00-000 Ground Mobility Research c. Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of d. Military Vehicles	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355 Report 2 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES U. S. Forest Service collaborated in this study.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The soil-moisture prediction method previously found applicable to U. S. sites was found applicable also to 8 Puerto Rico prediction development sites. Predictions based on data collected at these 9 sites were reasonably accurate when applied to 22 other sites in Puerto Rico; predictions based on U. S.-derived data were somewhat less accurate, principally because soil-moisture depletion rates in Puerto Rico are considerably different from those in the U. S. It was found that (a) Puerto Rico soils do not lose moisture as fast as U. S. soils, and the rate of loss seems to be unaffected by season; and (b) the average rate of daily moisture depletion in the surface to 12-in. layer of Puerto Rico soils is about 1/2 the average summer rate and about equal to the spring-autumn rate in humid climates of the U. S. Soil-moisture content correlated fairly well with both cone index and rating cone index but poorly with remolding index.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Puerto Rico]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PANAMA STUDY NO. 2 (OCTOBER 1961 - SEPTEMBER 1963)

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 3 of a series

5 AUTHOR(S) (Last name, first name, initial)

McDaniel, Alvin R.

6. REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
August 1966	134	17

8a. CONTRACT OR GRANT NO b PROJECT NO 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -02, Surface Mobility d	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355 Report 3 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 801 321

10 AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command, Washington, D. C. 20315

13 ABSTRACT

Soil trafficability studies have shown that the strength of a soil is of major importance to vehicle mobility and varies principally with soil moisture; therefore, a means of predicting moisture content of a soil is essential to the forecasting of soil trafficability. The U. S. Army Engineer Waterways Experiment Station soil-moisture prediction method for U. S. soils was applied to sites located in the Panama Canal Zone to determine whether the method was applicable for the prediction of moisture content of tropical soils. Factors necessary for the predictions were obtained at specific sites, and analysis of data shows that the method is applicable to Panama soils. Groundwater did not have an appreciable influence on soil-moisture depletion since drainage from the 0- to 12-in. layer was rapid. An analysis of strength data showed a highly significant relation between moisture content and cone index, and a lesser degree of significance between moisture content and rating cone index. No relation was found between moisture content and remolding index. On the basis of rating cone index, the trafficability of the residual soils was considered good. Trafficability of the alluvial marshland soils was considered good during the dry season and poor during the wet season.

KEYWORDS: Soil-moisture prediction; Trafficability prediction; Tropical regions; [Panama Canal Zone]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; COLOMBIA STUDY (JULY 1962-JULY 1963)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 4 of series

5. AUTHOR(S) (First name, middle initial, last name)

Alvin R. McDaniel

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1967	75	9

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355 Report 4 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 824 734L

10. DISTRIBUTION STATEMENT

Distribution limited to U. S. Government agencies only; foreign information; 15 November 1971. Other requests for this document must be referred to U. S. Army Materiel Command.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The U. S. Army Engineer Waterways Experiment Station (WES) soil-moisture prediction method for United States soils was applied to sites in Colombia to determine whether the method was applicable for the prediction of moisture content of tropical soils.

Data were collected at four prediction development sites in the subhumid climate of the "Sabana de Bogota" located in the Andean Mountain ranges of Colombia. Changes in soil-moisture content, soil density, and soil strength with changes in weather conditions were investigated periodically for one year.

These data were analyzed and used to predict daily soil-moisture content and to establish the relation between soil moisture content and soil strength. The results show that the WES soil-moisture prediction method is applicable to prediction of soil-moisture content at the four sites in Colombia. Data were of sufficient quantity to establish soil-moisture depletion curves for each site but not of sufficient quantity to establish accretion relations. Relations were established between soil-moisture content and soil strength at all sites. Trafficability of the soils tested, as indicated by rating cone index, was good even when the soils were at maximum moisture content.

Basic data and photographs for each test site are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Colombia, S.A.]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; Report 5, COSTA RICA STUDY NO. 1 (JANUARY 1963 - JANUARY 1965)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 5 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Alvin R. McDaniel

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1967	99	8

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355 Report 5
b. PROJECT NO. 1-V -0-21701-A-046, Trafficability and Mobility Research c. Task-02, Surface Mobility	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 824 882L
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Soil trafficability studies have shown that the strength of a soil is of major importance to vehicle mobility and varies principally with soil moisture; therefore, a means of predicting moisture content of a soil is essential to the forecasting of soil trafficability. The U. S. Army Engineer Waterways Experiment Station (WES) soil-moisture prediction method for United States soils was applied to sites in Costa Rica to determine whether the method was applicable for the predition of moisture content of tropical soils. Data necessary for the predictions were collected on five sites in the Premontane wet climate of the Reventazón Valley at Turrialba, Costa Rica. Changes in soil moisture content, density, strength, and remolding strength with changes in weather conditions were investigated at regular intervals for 25 months. These data were analyzed and used to predict soil-moisture content and to establish the relation between moisture content and soil strength. The analysis shows that the WES method is applicable to prediction of soil-moisture content at the five sites in Costa Rica. Groundwater did not have an appreciable influence on soil moisture depletion since drainage from the 0- to 12-in. (0- to 30.5-cm) soil layer was related directly to rainfall. Topography was shown to influence soil-moisture content to some degree. Analysis of strength data showed a highly significant relation between soil strength and moisture content. On the basis of rating cone index, the trafficability of the soils was considered poor during the wet season and good during the latter part of the dry season. Basic data and photographs for each test site are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Costa Rica]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PUERTO RICO STUDY NO. 2 (MARCH 1962 - NOVEMBER 1963)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 6 in a series

5. AUTHOR(S) (First name, middle initial, last name)
James G. Kennedy
Thomas E. Hicks

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1968	263	38

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1V021701A046	Miscellaneous Paper No. 4-355, Report 6
c. Task 02	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	AD 845 616

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT
The soil moisture prediction method for soils in the U. S. was previously applied to eight sites in Puerto Rico and was found applicable to those soils. The study reported herein was to determine whether the prediction method was applicable, without major modifications, to other sites in Puerto Rico. Factors necessary for the predictions were obtained at specific sites, and analysis of data shows that the method is applicable to Puerto Rican soils; however, it was necessary to modify the method when the groundwater table was within the surface foot for prolonged periods. Groundwater did not have an appreciable influence on soil moisture depletion when the water table occurred within the surface foot for a short period, since drainage from this layer was rapid. At sites where water tables existed within the surface foot for prolonged periods, the derived depletion curves were not applicable. An analysis of strength data showed a highly significant relation between moisture content and cone index, and a lesser degree of significance between moisture content and rating cone index. Only 3 of 29 test sites showed any relation between moisture content and remolding index. On the basis of rating cone index, it appears that sites within the playas and alluvial plains of Puerto Rico may present trafficability problems throughout the year. Other areas with good drainage and seasonal rainfall may not be trafficability problem areas except during the extremely wet period. Basic data and photographs for each test site are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Puerto Rico]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; Report 7, HAWAII STUDY	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Report 7 of a series	
5. AUTHOR(S) (First name, middle initial, last name) C. A. Carlson W. P. Bonnert, Jr. M. P. Meyer	
6. REPORT DATE November 1970	7a. TOTAL NO. OF PAGES 113 7b. NO. OF REFS 9
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046 (Task 02) and 1T062109A131 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355, Report 7 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 877 577
10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Soil trafficability studies have shown that the strength of a soil is of major importance to vehicle mobility and that strength varies principally with soil moisture; therefore, a means of predicting moisture content of a soil and knowledge of the relation between soil moisture and strength are essential to the forecasting of soil trafficability. The U. S. Army Engineer Waterways Experiment Station soil-moisture prediction method was applied to sites in Hawaii to determine whether the method was valid for the prediction of moisture content of these tropical soils. Data were collected from January 1960 to June 1961 at 34 sites, on three Hawaiian islands, representing the major soils, weather regimes, terrains, and land uses in Hawaii. The data from 11 sites were analyzed and used to predict daily soil moisture contents, and data from all sites were used to determine the relations between moisture content and soil strength. The moisture prediction method was found valid. Relations were found between moisture content and strength, but at many sites they were poor due to the variability of the soil. In terms of rating cone index, the trafficability of the upland allophane clays was poor throughout the year. Trafficability was periodically poor following high rainfalls on an upland soil with a perched water table and on soils from alluvium in the lowlands. Other upland soils had good trafficability throughout the year. Basic data are included as Appendix A.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Hawaii]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; Report 8, COSTA RICA STUDY NO. 2 (JANUARY 1964-SEPTEMBER 1965)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 8 of a series

5. AUTHOR(S) (First name, middle initial, last name)
Alvin R. McDaniel
Margaret H. Smith

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1971	201	15

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-355, Report 8
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c. Task 02	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
Distribution limited to U. S. Government agencies only; foreign information; 11 May 1971. Other requests for this document must be referred to AMCRD-TV.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT
A U. S. Army Engineer Waterways Experiment Station (WES) soil moisture prediction method was modified to permit predictions to be made with a limited amount of information from a site. Using this method of prediction and precipitation records from weather stations, a system of mapping soil moisture contents throughout Costa Rica is presented. Using these maps, soil moisture contents can be determined for any site with knowledge of only the field-minimum and field-maximum moisture contents of the soil. Soil moisture predictions made for 65 Costa Rica sites using the modified method compare favorably with predictions made in the United States using the WES soil moisture prediction method. Soil strengths, in terms of cone index, were predicted using a general Costa Rica soil moisture-soil strength relation and using specific site relations derived by simple linear regression and reduced major axis regression techniques. When predictions with the general Costa Rica relation were compared with measured cone indexes they fell far short of the accuracy of the predictions using the other two prediction techniques. Therefore, this simplified method was abandoned as a reliable prediction method, and predictions of cone index and rating cone index using only the simple linear regression relations are presented.

KEYWORDS: Soil moisture prediction; Trafficability prediction; Tropical regions; [Costa Rica]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PRELIMINARY STUDY OF STRESSES UNDER OFF-ROAD VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Green, J. E.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
October 1959	19	5

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-362
b. PROJECT NO. c. Subproject No. 8-70-05-400, Trafficability of Soils as Related to d. Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 841 349

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at Annual Convention of American Society of Civil Engineers, October 1959	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This paper presents an account of the preliminary research into the area of soil mechanics dealing with vehicle-soil relations conducted by the Army Mobility Research Branch of the Waterways Experiment Station, and describes the test procedures used and the results obtained.

KEYWORDS: Soil-vehicle interaction; Stresses under vehicles; Test procedures

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFIC EVALUATION TESTS OF ROGERS DRY LAKE, CALIFORNIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Loren M. Womack

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-365 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

A portion of the unsurfaced runways of Rogers Dry Lake, Edwards Air Force Base, California, was subjected to traffic applied with a test load cart having a gross weight of 280,000 lb and carried on a twin-twin gear assembly. Tire inflation pressures ranged between 275 and 325 psi. The primary objectives of traffic were to determine (a) whether the soil strength of the lake bed was adequate to support a load of this magnitude, and (b) the effect of load repetition on the load-carrying capacity of the soil. It was also desired to determine the rate of pressure build-up that might be expected in tires inflated with air only and towed over a prescribed route. The traffic resulted in some settlement of the soil and also the displacement of a friable crust of varied thickness in some of the areas tested.

KEYWORDS: Military bases; Soil strength; Traffic tests; Unsurfaced airfields; Unsurfaced runway performance and evaluation; [Edwards Air Force Base; Rogers Dry Lake]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

LABORATORY TESTS OF LIQUID NITROGEN SOIL-MOISTURE SAMPLERS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Burke, H. D.
Krumbach, A. W.
Rush, E. S.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b PROJECT NO 8-70-00-000 Ground Mobility Research c Subproject 8-70-05-400, Trafficability of Soils as Related to the Mobility of d Military Vehicles	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-371 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 311

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
U. S. Forest Service collaborated in this study.	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

This limited laboratory study was made to determine whether a method for quick-freezing and extracting soil samples provided more accurate determination of moisture content than did mechanical samplers, particularly for very wet soils. The quick-freezing was accomplished with liquid nitrogen poured into a hollow probe inserted in the soil. In tests on soils whose moisture contents ranged to well above the liquid limit, it was determined that accuracy with the quick-freeze method was almost as good as with the mechanical samplers. This conclusion was based mainly on reproducibility of results. The liquid nitrogen probe was used over a range of soil-moisture contents, the sampling of which normally requires use of three types of mechanical samplers.

KEYWORDS: Laboratory tests; Liquid nitrogen; Soil moisture measuring devices; Soil samplers

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

STRENGTH REQUIREMENTS IN UNSURFACED SOILS FOR AIRCRAFT OPERATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Willard J. Turnbull
Audley A. Maxwell
Cecil D. Burns

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1960	14	4

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Miscellaneous Paper No. 4-394
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

This paper describes the development and validation of criteria for determining soil-strength requirements in unsurfaced soils for operation of aircraft.

KEYWORDS: Soil strength; Subgrades; Traffic tests; Unsurfaced airfields

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE ARMY MOBILITY RESEARCH CENTER TESTING FACILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1960	23	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-404
b. PROJECT NO. Subproject No. 8-70-05-400, Trafficability of Soils as Related to Mobility of Military Vehicles	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in The Military Engineer, May-June 1960, Vol.52, No.347.	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This paper describes in detail the ground mobility research laboratory established at the Waterways Experiment Station. All components in the laboratory are described, together with procedures employed in the research being conducted. This laboratory, with its facilities for the careful control and measurement of vehicle and soil features, and its flexibility and speed of operation, is ideally suited for the engineering research needed to develop the principles of vehicle operation on all kinds of terrain. It is expected that this research will lead to the production of Army ground vehicles with the highest mobility characteristics. (See Technical Report No. 3-666, Report No. 1, for a more up-to-date report on the mobility laboratory.)

KEYWORDS: Mobility research laboratories; [Waterways Experiment Station]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A LIMITED STUDY OF THE PERFORMANCE OF THE 2-TON MEILI FLEX-TRAC

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject No. -02, Surface Mobility (Trafficability) d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-412 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 321

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The Flex-Trac, a multipurpose cross-country, six- and four-wheel-drive vehicle, is articulated vertically at the wheel-base center, enabling the vehicle to assume a sway-back position (front or rear end higher than center), an arched-back position (center wheels off ground), or a "float" position (free articulation of all wheels). Self-propelled and towing tests were made on soft, level terrain to determine performance characteristics in terms of soil strength required for operation, sinkage, slippage, and drawbar pull, and to determine cone index requirements with the vehicle in six- and four-wheel drive in the various positions. From these limited tests the vehicle appears able to operate on soil of slightly lower strength than estimated from the computed cone index. The principal contributing factor to the possibly better performance is the balanced weight distribution on the six wheels. Excerpts from the manufacturer's brochure are included as Appendix A.

KEYWORDS: Articulated vehicles; Field tests; Mobility; Tracked vehicles; Trafficability; [Flex-Trac Vehicle]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
PHYSICAL COMPONENTS OF THE SHEAR STRENGTH OF SATURATED CLAYS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

H. Juul Hvorslev

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO	Miscellaneous Paper No. 3-428
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Proceedings of ASCE Research Conference on Shear Strength of Cohesive Soils, Univ. of Colorado, Boulder, Colo., June 1960	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The paper deals primarily with the physical components of the shear strength of remolded, saturated clays and with the various factors which influence these components. The results of subsequent research by others are taken into consideration and summarized when appropriate, but the paper is not a complete review of the very extensive and important research on shear strength of saturated clays performed during the last twenty years. The sources of error in the tests performed by the writer are discussed, and emphasis is placed on clarification of the assumptions and limitations relating to the conclusions and formerly proposed criteria for the shear strength of saturated clays.

KEYWORDS: Clays; Saturated soils; Shear strength (Soils); Soil strength

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY TESTS WITH JUMBO TRUCK ON ORGANIC AND COARSE-GRAINED MINERAL SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-438 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 331

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Trafficability tests were conducted to investigate performance in soft muck and clean sand of the Jumbo, a 5-ton 4x4 truck fabricated from commercially available components and equipped with large (18.00-26) tires. In muck, the Jumbo could complete 40 to 50 passes on areas with a rating cone index of 56, several points lower than cone indexes required for wheeled military vehicles of approximately the same weight. In sand, the Jumbo easily climbed grades that could not have been negotiated by an M135 2-1/2-ton 6x6 cargo truck at the same tire pressures. The limited test program indicated the Jumbo to be a better soft-ground-crossing vehicle than standard military vehicles of approximately the same weight. Additional testing, particularly in soft mineral soils and soft snow, is needed to evaluate the vehicle fully. The computations for determining the vehicle cone index of the Jumbo truck for operation in fine-grained soils are included as Appendix A.

KEYWORDS: Field tests; Mobility; Organic soils; Sands; Trafficability; Trucks; Wheeled vehicles; [Jumbo Truck]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY TESTS WITH THE AIROLL ON ORGANIC AND MINERAL SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.
Rula, A. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	Miscellaneous Paper No. 4-439 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD A006 497

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The Airoll represents a new concept of locomotion. Its propulsion system comprise free-rolling, low-pressure, pneumatic tires mounted on endless chains rotating about driving sprockets and return idlers. It can move with two different and distinct types of action of the tires on the ground--rolling-wheel track and stationary-wheel track actions. Self-propelled, towing, and towed tests were conducted on a range of soils to determine the Airoll's performance under off-road conditions. Results indicate that (a) it can travel on soft muck and wet fine-grained soils negotiable by no known military vehicle of equal weight; (b) its slope-climbing ability in clean sand compares with that of tracked vehicles; (c) its towing ability on firm soil is less than that of tracked vehicles; (d) the force required to tow it compares with that required for tracked vehicles; and (e) its rolling-wheel and stationary-wheel track features give it greater travel efficiency on most soils than tracked vehicles. Appendix A describes the Airoll suspension system; Appendix B gives the computations of its vehicle cone indexes.

KEYWORDS: Airoll vehicles; Field tests; Fine-grained soils; Mobility; Organic soils; Trafficability

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

MEASUREMENT AND ESTIMATION OF THE TRAFFICABILITY OF FINE-GRAINED SOILS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Rula, A. A.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO. b. PROJECT NO 8S70-05-001 Trafficability and Mobility Research c. Subproject No. 02, Surface Mobility (Trafficability) d	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-441 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Presented at the First Int Conference on Soil Vehicle Systems, Turin, Italy, 12-15 June 1961.	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

Instruments and techniques developed by the U. S. Army Corps of Engineers for the direct measurement and remote estimation of the trafficability of fine-grained soils and prediction of performance of military vehicles are summarized in this paper. A simple, empirical measure of soil strength, called rating cone index, adequately describes the trafficability of a fine-grained soil and serves as the basis for confident prediction of military vehicle performance in terms of single or multiple passage across a level area, drawbar pull available for towing loads or climbing slopes, and forces required to tow nonself-propelled vehicles.

KEYWORDS: Fine-grained soils; Mobility; State-of-the-art studies; Trafficability; Trafficability prediction; Trafficability test instruments

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SOIL TRAFFICABILITY CLASSIFICATION SCHEME

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Meyer, M. P.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-442 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES This paper presented at the meeting of the International Society of Terrain-Vehicle Systems in Turin, Italy, June 1961.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

A study was made of pertinent soil trafficability data collected during the wet season at more than 1300 sites located principally in humid-temperate regions of the United States. The soils were identified according to the Unified Soil Classification System and U. S. Department of Agriculture textural classification system, topographic position, and two general levels of wetness. A scheme for classifying soils according to their trafficability was developed. The scheme lists the soil types in order of decreasing strength under each of four topography-general wetness level categories, and shows the probability of successful passage on each soil for vehicles with known soil strength requirements. This scheme permits the estimation of the probability of a successful operation under given soil type, topography, and general wetness level conditions. Given the choice of several routes and vehicles, the determination can be made of the vehicles with the best chances of success over a given route or which route is best for given vehicles.

KEYWORDS: Soil strength; Statistical distributions: Trafficability classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	**2a REPORT SECURITY CLASSIFICATION** Unclassified **2b GROUP**

3. REPORT TITLE

THE BEHAVIOR OF SAND UNDER PNEUMATIC TIRES

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Turnbull, W. J.
Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b NO. OF REFS
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8a CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001, Trafficability and Mobility Research c. Subproject -03, Mobility Fundamentals and Model Studies d.	**9a. ORIGINATOR'S REPORT NUMBER(S)** Miscellaneous Paper No. 4-443 **9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)**

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES Presented at First Int Conf on Soil-Vehicle Systems, Turin, Italy, 12-15 June 1961; Published in Proceedings, Paper 32.	**12. SPONSORING MILITARY ACTIVITY** Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Tests to determine the behavior of sand under pneumatic tires are being conducted in a special facility of the Army Mobility Research Branch of the Waterways Experiment Station. The operation of a dynamometer carriage-soil bin system provides a continuous record of the performance of a tire or track for slip values ranging from slightly negative to 100 percent. Tests with three pneumatic tires of the same overall diameter but of different cross-section widths have been conducted on an air-dry sand. Results show that the performance of these tires on the first pass is dependent only upon wheel load and sinkage. If other factors exert an influence on performance, their effects are reflected in sinkage. The test data show that the total traction force developed by the test tires is approximately 0.39 times the tire load. These results are supported by an analysis of the forces acting on the wheel. Problems yet to be solved are outlined briefly.

KEYWORDS: Laboratory tests; Pneumatic tires; Sands; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

CLASSIFICATION OF TERRAIN FOR MOBILITY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. R. VanLopik, J. R. Compton

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Presented at First International Conference on the Mechanics of Soil-Vehicle Systems, Turin, Italy, June 1961	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers Department of the Army Washington, D. C.

13. ABSTRACT

The principal elements of landscape that affect the capability of vehicles to travel cross country are topography, surface composition and consistency, vegetative cover, and hydrography. These elements combined in various ways tend to deny and slow movement, decrease efficiency, increase maintenance, increase driver fatigue, and control direction. This paper presents a few techniques which have been developed to classify and map terrain elements in objective and fairly quantitative terms. Techniques of this type may eventually permit valid evaluations of trafficability and mobility characteristics of specific areas.

KEYWORDS: Mobility; Terrain classification; Terrain factors; Terrain mapping

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

COMPARISON OF TRAFFICABILITY OF MUSKEG WITH TRAFFICABILITY OF OTHER SOFT SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rula, A. A.

6. REPORT DATE	7a TOTAL NO OF PAGES	7b NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject No. -02, Surface Mobility (Trafficability) d.	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-446 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 754 332

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at Second Meeting of the Tripartite Working Group on Ground Mobility, Canada, September 1960.	Chief of Engineers, DA Washington, D. C. 20315

13 ABSTRACT

In this paper, the trafficability of muskeg is discussed in some detail and compared with that of other soft terrains, namely, muck, lacustrine, deltaic, and tidal land forms. Trafficability is compared on the basis of the respective strength profiles in the various soils and, where appropriate, on the basis of rating cone index. Other trafficability factors, such as slope, stickiness, and sliperiness, are discussed where applicable. The final assessment of the trafficability of soft terrain is made on the basis of the vehicles that this terrain will support.

KEYWORDS: Muskeg; Soft soils; Soil strength; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	**2a. REPORT SECURITY CLASSIFICATION** Unclassified **2b GROUP**

3. REPORT TITLE

PROPERTIES OF SURFACE SOILS IN THE WET SEASON

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Turnbull, W. J.
Knight, S. J.

6. REPORT DATE	7a TOTAL NO OF PAGES	7b NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject No. -02, Surface Mobility (Trafficability) d.	**9a ORIGINATOR'S REPORT NUMBER(S)** Miscellaneous Paper No. 4-447 **9b OTHER REPORT NO(S)** (Any other numbers that may be assigned this report) AD 754 335

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Presented at Fifth Int Conf on Soil Mechanics and Foundation Engineering, Paris, France, 17-22 July 1961; Published in Proceedings	**12 SPONSORING MILITARY ACTIVITY** Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Results are summarized of tests of moisture content, density, and strength of surface soils at several hundred sites in humid-climate areas of the Unit States. A first-order approximation of values of these properties on the basis of soil texture is indicated by a graphic analysis.

KEYWORDS: Soil property measurements; Soil texture; Statistical analysis; Temperate regions; Trafficability data

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SOME FACTORS AFFECTING MOISTURE CONTENT-DENSITY-CONE INDEX RELATIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1961	55	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001, Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-457 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 753 641

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This paper presents the results of a study conducted to determine what effect certain methods of handling soil samples before they are compacted and tested would have on moisture-density-cone index relations, if the compaction technique was kept constant. Four techniques of soil preparation, identified as re-use, Blakeslee mixing, Bonnot mixing, and air-dried, were used on three soils--a low-plasticity soil, a medium-plasticity soil, and a high-plasticity soil. Density-moisture content and cone index-moisture content curves were developed for moisture contents higher than optimum using the different soil-preparation techniques. These curves were compared with reference curves developed using preparation techniques normally used in trafficability studies. Since the density-cone index-moisture relations that resulted from the different preparations of the soils often differed significantly from the reference relations, it was recommended that the laboratory techniques currently used (i.e. those used in determining the reference relations) be continued in trafficability studies and that additional comparisons of field and laboratory relations be made, where feasible, with a view toward eventual development of criteria for extrapolating rating cone index-moisture content curves from laboratory cone index-moisture content curves.

KEYWORDS: Laboratory tests; Soil density; Soil moisture; Soil property relations; Soil strength; Trafficability

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Security Classification M,E

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

A TECHNIQUE FOR MAPPING TRAFFICABILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Meyer, M. P.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b NO OF REFS
December 1961	14	0

8a CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject No. -02, Surface Mobility (Trafficability) d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-461 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 754 334

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES This paper appeared in The Military Engineer, May-June 1962, Vol.54, No.359.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

This study provides a technique for portraying trafficability, developed by the Trafficability Section, WES. The method depends primarily on agricultural soils data (soil series and type) readily available in published form. The analysis is limited to general topography, soils, and vegetation in an area comprising Alabama and Georgia. The basic soil information is interpreted in terms of eight trafficability classes. Vehicle mobility of the M48 tank is described in terms of passable, doubtful, and impracticable under soil-moisture conditions including dry-season average conditions, wet-season average conditions, and maximum moisture conditions.

KEYWORDS: Trafficability classification; Trafficability mapping; [Alabama; Georgia]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MEASURING SOIL TRAFFICABILITY CHARACTERISTICS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-462
b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject -02, Surface Mobility (Trafficability) d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 754 333

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Presented at the American Society of Agricultural Engineers, Chicago, Ill., 12-15 December 1961, Paper 61-609.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The Army's need to predict the performance of military vehicles in a wide range of soil and snow conditions has been met by the results of an empirical test program. Soil and snow conditions were quantitatively indicated in terms of the resistance offered by the soil and snow to being probed with a simple instrument, called the cone penetrometer, and vehicles were tried out on various soil and snow conditions. On the basis of statistical evidence, vehicle performance and cone index have been correlated. The results of the Army study may possibly be applied to the solution of agricultural problems involving the interrelations of tractors and soils.

KEYWORDS: Cone penetrometers; Trafficability test instruments

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STRESSES IN YIELDING SOILS UNDER MOVING WHEELS AND TRACKS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO b. PROJECT NO. 8S70-05-001, Trafficability and Mobility Research c. Subproject -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-463 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Presented at Annual Meeting of Highway Research Board, Washington, D. C., January 1962; published in HRB Bulletin 342.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

The status of the stress measurement program at the Waterways Experiment Station is presented in this paper. It describes the equipment and techniques employed in the study, some of the difficulties encountered, and the results obtained thus far.

KEYWORDS: Soft soils; Stresses under tracks; Stresses under wheels; Trafficability test instruments

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
DISTRIBUTION OF STRESSES ON AN UNYIELDING SURFACE BENEATH A PNEUMATIC TIRE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Freitag, D. R.
Green, A. J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1962	19	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001, Trafficability and Mobility Research c. Subproject -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-469 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES Presented at Annual Meeting of Highway Research Board, Washington, D. C., January 1962; published in H.R.B. Bulletin 342.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT
A basic understanding of how soft, yielding soils support and provide traction to wheeled and tracked vehicles must be developed. One phase of the research being conducted at the U. S. Army Engineer Waterways Experiment Station to acquire this knowledge is concerned with the distribution of stresses induced by a pneumatic tire in the medium on which it operates. It includes the measurement of stresses at the interface between the tire and the surface that supports it and at locations within a yielding mass of soil. This paper describes results obtained from that portion of the research dealing with the interface stresses beneath a pneumatic tire on an unyielding surface.

KEYWORDS: Pavements; Pneumatic tires; Stresses under wheels

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)		
1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.		2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE TRAFFICABILITY TESTS WITH THE 5-TON GOER (XM520) ON FINE- AND COARSE-GRAINED SOILS		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report		
5. AUTHOR(S) (Last name, first name, initial) Rush, E. S.		
6. REPORT DATE April 1962	7a. TOTAL NO. OF PAGES 32	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-477 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 646 591	
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315	

13. ABSTRACT

Tests were conducted in soft, fine-grained soils and clean sand to determine performance characteristics of the 5-ton GOER for two tire sizes. In fine-grained soils the GOER performed better with 18.00-26 tires than with 15.00-34 tires. With 18.00-26 tires it performed better than standard military 6x6 wheeled vehicles of 2-1/2- and 5-ton capacity. In sand the GOER also performed better with 18.00-26 tires than with 15.00-34 tires. In one specific clean sand its performance with either size tire was better than any wheeled vehicle tested to date by WES. Additional testing, particularly in snow, sand, and muskeg, is needed to evaluate the vehicle fully. The computations for determining the vehicle cone index of the GOER for operation in fine-grained soils are included as Appendix A.

KEYWORDS: Field tests; Fine-grained soils; Goer vehicles; Mobility; Pneumatic tires; Sands; Trafficability; Wheeled vehicles; [Goer (XM520)]

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
U. S. Army Engineer Waterways Experiment Station	Unclassified
	2b. GROUP

3. REPORT TITLE

PREDICTING SOIL-MOISTURE DISTRIBUTION IN AREAS OF SEASONAL FROST, FEASIBILITY STUDY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. R. VanLopik, Charles R. Kolb

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
April 1962	51	88

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Miscellaneous Paper No. 3-482
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Division, New England

13. ABSTRACT

This report reviews the pertinent factors involved in predicting soil-moisture distribution patterns in areas of seasonal frost. Although the factors affecting such prediction methods are varied and complexly interrelated, it is concluded that useful prediction methods can be developed. It is recommended that a preliminary phase of the investigation be undertaken involving (a) the mapping of important soils-hydrologic conditions in the frost-susceptible region of North America as a guide for intelligently selecting sites for further field investigation; (b) the use of field sites, for which considerable data are already available, for detailed study of frost phenomena; and (c) a laboratory experiment to isolate variables affecting moisture and frost distribution under controlled conditions. A paper on prediction of soil moisture from soil and weather records is included herein as Appendix A.

KEYWORDS: Feasibility studies; Freeze-thaw; Frost susceptible soils; Soil moisture prediction, Temperate regions; Subarctic regions

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Unclassified
Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified	2b. GROUP
3. REPORT TITLE DEFLECTION OF A MOVING TIRE ON FIRM TO SOFT SURFACES		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report		
5. AUTHOR(S) (Last name, first name, initial) Knight, S. J. Green, A. J.		
6. REPORT DATE May 1962	7a. TOTAL NO. OF PAGES 19	7b. NO. OF REFS 4
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001, Trafficability and Mobility Research c. Subproject -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-497 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.		
11. SUPPLEMENTARY NOTES Presented at Winter Meeting of American Society of Agricultural Engineers, Chicago, Ill., 11-14 December 1962, Paper 62-646; Trans. ASAE, Vol 5, No. 2.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315	

13. ABSTRACT

An estimate of the stresses imparted by pneumatic tires to surfaces on which they operate was sought by making a study of the shape a tire assumes under various loads and inflation pressures on various media. Circular-linear potentiometers mounted inside the tire provided means for determining the cross-s tion shapes

KEYWORDS: Pneumatic tires; Stresses under wheels; Tire deflection

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

OPERATION WHEELTRACK, CAMP A. P. HILL, VIRGINIA, 25-30 APRIL 1962

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1962	21	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8S70-05-001 Trafficability and Mobility Research c. Subproject 8S70-05-001-02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-505 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

Operation Wheeltrack was a cooperative test program among U. S. Army Ordnance Corps (Ordance Tank-Automotive Command), U. S. Army Transportation Corps (U. S. Army Transportation Board and U. S. Army Transportation Research Command), and U. S. Army Corps of Engineers (U. S. Army Engineer Waterways Experiment Station) to determine performance characteristics of military support vehicles in varied terrain conditions. Since WES did not take part in the development of the test program and because of lack of manpower to staff a field test crew, WES participation was only a token effort. Trafficability data collected and reported in this report were believed typical of those collected at other areas during Operation Wheeltrack. It is recommended that the results be compared with results reported in the final report on Operation Wheeltrack when it is published.

KEYWORDS: Field tests; Military bases; Military vehicles; Offroad mobility; Trafficability; Trafficability data; [Camp A. P. Hill, Virginia]

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1. ORIGINATING ACTIVITY (Corporate author)

U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION

Unclassified

2b. GROUP

3. REPORT TITLE

AIROLL PERFORMANCE IN SNOW

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Smith, N. H.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1962	14	0

8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 8S70-05-001
Trafficability and Mobility Research
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d.

9a. ORIGINATOR'S REPORT NUMBER(S)

Miscellaneous Paper No. 4-513

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Chief of Engineers, DA
Washington, D. C.

13. ABSTRACT

During the period 1-21 February 1962, snow trafficability tests were conducted at Camp Hale, Colorado, to determine the performance characteristics of several standard military tracked vehicles and an experimental test platform (Airoll) operating in subarctic snow. The program included tests in which snow, terrain, and vehicle performance data were collected for correlation purposes. In this paper, the performance of the Airoll is compared with that of the M29C weasel, since the weasel has excellent performance characteristics in soft terrain.

KEYWORDS: Airoll vehicles; Field tests; Military bases; Mobility; Snow trafficability; Tracked vehicles; [Camp Hale, Colo.; M29C Weasel]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
REPORT OF MOBILITY CONSULTANTS CONFERENCE
Waterways Experiment Station, Vicksburg, Mississippi, 13-15 June 1972

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Progress report to June 1962

5. AUTHOR(S) (First name, middle initial, last name)
Not applicable

6. REPORT DATE August 1962	7a. TOTAL NO. OF PAGES 308	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Unnumbered 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This report summarizes the discussions in a meeting held at the U. S. Army Engineer Waterways Experiment Station on 13-15 June 1962 of a board of consultants, representatives from the Office, Chief of Engineers, and Waterways Experiment Station personnel on the subject of mobility research. Subjects discussed include a review of mobility studies at WES (S. J. Knight), relation of MEGA and mobility studies (J. R. Compton), single wheel tests in sand (C. J. Powell), single wheel tests in clay (R. D. Wismer), soil strength measurements (J. L. Smith), tire configuration studies (M. E. Smith), some fundamental mobility studies (A. J. Green, Jr.), review of Bekker theory (Dr. M. J. Hvorslev), review of load-flow theory (W. G. Shockley), review of CARDE theory (R. D. Wismer), and WES concept of mobility research (R. G. Ahlvin).

KEYWORDS: Meetings; Mobility; State-of-the-art studies

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

DOCUMENTATION OF CONDITIONS ATTENDANT TO ARMY TACTICAL MOBILITY REQUIREMENTS (HOWZE) BOARD TESTING

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

R. G. Ahlvin and E. E. Garrett

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Miscellaneous Paper No. 4-526
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
This document is a Memorandum for Record	Office, Chief of Engineers Department of the Army Washington, D. C.

13. ABSTRACT

A documentation of environmental (vegetation, macrogeometry and microgeometry) and related conditions at tests involving engineer effort for items and at places as follows: (a) air-mobile engineer support (Ft. Bragg); (b) air-mobile refueling task force (Ft. Bragg); (c) bomb-crater repair in airstrips (Ft. Bragg and Mackall Field); (d) landing strip construction (Ft. Stewart, Ga.); (e) explosive preparation of helicopter landing sites (Ft. Bragg); and (f) multiple C-130 landings at Falcon airstrip (Ft. Bragg). Testing was conducted from May to July 1962.

KEYWORDS: Airfield construction; Engineering effort; Helicopter landing zones; Military bases; Temperate regions; Terrain analysis; [Ft. Bragg, N.C.; Ft. Stewart, Ga.]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

A TECHNIQUE FOR ESTIMATING THE SLOPE-CLIMBING ABILITY OF WHEELED VEHICLES IN SAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.
Knight, S. J.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b NO. OF REFS
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8a CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c. Subproject -02, Surface Mobility	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10 AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES Presented at the Society of Automotive Engineering Congress and Exposition, Detroit, Michigan, January 1963, Paper 623E.	12. SPONSORING MILITARY ACTIVITY Chief of Engineers, DA Washington, D. C. 20315

13. ABSTRACT

In a test program jointly supported by the Army and the Navy, the U. S. Army Engineer Waterways Experiment Station has conducted approximately 2500 tests of the ability of wheeled military vehicles to climb slopes of loose sand. Tests were conducted on a variety of beach and dune sands. Test procedures and techniques are described briefly. The strength of the sand on the slopes was measured by means of a cone penetrometer. The slope-climbing performance of each of the five sizes of vehicles tested is shown to be determined principally by the strength of the sand and by tire size and inflation pressure. An empirical method employing firm-surface tire-print data, wheel load, and sand strength is presented as a means of predicting the sand slope-climbing capability of conventional all-wheel-drive vehicles.

KEYWORDS: Coarse-grained soils; Field tests; Military vehicles; Slope performance; Trafficability; Wheeled vehicles

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

IDENTIFYING SOIL PARAMETERS WITH AN INFRARED SPECTROPHOTOMETER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Shockley, W. G.
Knight, S. J.
Lipscomb, E. B.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research c. Task -04, Mobility Terrain Analysis and Symbology d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-547 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 220

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Published in Proceed. of Second Symposium on Remote Sensing of Environment, University of Michigan, October 1962.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This paper discusses the overall aims and objectives of the Waterways Experiment Station program in terrain interrogation using sensors operating in certain portions of the electromagnetic spectrum, describes the infrared equipment and tests conducted, and analyzes results obtained.

KEYWORDS: Infrared detectors; Infrared rays; Laboratory tests; Remote sensing; Soils; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

VISIT TO SWAMP FOX II OPERATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Rush, E. S.
Garrett, E. E.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-T-0-21701-A-046 Trafficability and Mobility Research c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-556 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES See TR 3-609 for Swamp Fox I operation.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Operation Swamp Fox II (U. S. Army Transportation Board Project TCB-62-176-EO) was the third of a series of environmental operations conducted by the Transportation Board in the Republic of Panama, and was designed to provide more complete scientific-engineering research of environment-vehicle relation by establishing a base camp and conducting tests under controlled conditions. Most of the basic trafficability data was made available to the U. S. Army Engineer Waterways Experiment Station observers by the mobility test team because WES participation was limited to the period 29 September-15 October 1962. The analysis was made by the authors. The other data and information reported were collected, at least in part, by the authors. This memorandum was prepared for record purposes.

KEYWORDS: Field tests; Military vehicles; Mobility; Trafficability; Tropical regions; [Panama; Swamp Fox]; Terrain analysis

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TERRAIN EVALUATION FOR MOBILITY PURPOSES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau

6. REPORT DATE July 1963	7a. TOTAL NO. OF PAGES 19	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 3-592 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 216	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Paper prepared for publication in Journal of Terramechanics, Vol.1, No.2, 1964, pp.22-32.	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers Department of the Army Washington, D. C.

13. ABSTRACT

This paper describes the study of the effects of terrain on military activities; most of the effort so far has been concentrated on a study of the environment as it affects vehicular mobility. The families of the factors thus far dealt with are surface geometry, surface composition, hydrologic geometry, and vegetation. The surface geometry family is concerned only with the physical shape of the surface of the earth and is subdivided into the gross surface geometry (macrogeometry) and the minor surface irregularities (microgeometry). An arbitrary relief of 10 ft has been selected as the dividing criterion. The surface composition family is concerned with the physical characteristics of the materials of which the surface is composed. The shape, size, and distribution of water bodies of all kinds are characteristics described by the hydrologic geometry family. The vegetation factor family is concerned only with the geometry of the vegetation structure as a whole and not with the taxonomy of the individual plants. On the basis of tests, it was determined that (a) surface microgeometry exhibits the greatest effect on vehicular movement, and (b) critical tree spacing appears to be more closely related to vehicle length and not to turning radius.

KEYWORDS: Mobility; Terrain analysis; Terrain classification; Terrain factors

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

VISIT TO UNIVERSITY OF ILLINOIS TO DISCUSS TROPICAL SOILS STUDY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Carlson, C. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1-T-0-21701-A-046 Trafficability and Mobility Research c. Task -02, Surface Mobility d.	Miscellaneous Paper No. 4-594 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 217

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Professor D. U. Deere summarized his experiences in the testing and use of tropical soils. Many soils contain minerals that dry irreversibly; hence, all laboratory testing of tropical soils must be started with field-moist material. Even with this precaution, prescribed optimum moisture-density values could not always be obtained in the field because of a continually wet environment. Chemical and mineralogical analyses were suggested to determine what constituents and soils were subject to irreversible drying.

KEYWORDS: Meetings; Soil tests (Laboratory); Trafficability; Tropical regions

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STUDY OF THE CHARACTERISTICS OF RICE FIELDS IN THE UNITED STATES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Kennedy, J. G.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
October 1963	53	21

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. ARPA Order No. 400 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-602 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 215

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Service agent. U. S. Army Materiel Command Washington, D. C. 20315	Advanced Research Projects Agency Washington, D. C. 20315

13. ABSTRACT

This is a report of the first of many trips made to rice fields in Stuttgart and Kelso, Ark., and Crowley, La., in a study to determine seasonal characteristics of the rice fields pertinent to military operations. Soil, terrain geometry, vegetation, and hydrologic geometry data collected during the peak of the wet season are reported and discussed.

KEYWORDS: Mobility; Rice fields; Terrain factors; Trafficability data; [Arkansas; Louisiana]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

SPEED TESTS CONDUCTED IN CANADA DURING MUSKEG TRAFFICABILITY TEST PROGRAM, AUGUST 1962

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Schreiner, B. G.

6. REPORT DATE	7a TOTAL NO OF PAGES	7b. NO. OF REFS
July 1963	23	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-621 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 219

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES This study was a joint U.S.-Canadian research program.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

During the period 23 July-24 August 1962, trafficability tests were conducted on confined muskeg in the vicinity of Parry Sound, Ontario, Canada, to develop suitable correlations between vehicle performance and characteristics of organic terrain (muskeg). This paper discusses two special tests conducted on 9 and 10 August with six vehicles to determine the "maximum-safe" speed with which the vehicles could traverse a specific test course (test 1) and to determine the "normal cross-country" speed over the same test course (test 2). The vehicles are rated according to speed, quality of ride, and maneuverability. Factors affecting the tests are also discussed.

KEYWORDS: Field tests; Military vehicles; Mobility; Muskeg; Trafficability; Vehicle speed; [Canada; Parry Sound]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

COMMENTS ON MOBILITY RESEARCH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1964	17	5

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	Miscellaneous Paper No. 4-623 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 221

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES Presented at National Congress of the Society of Automotive Engineers, Detroit, Mich., January 1964, Paper 782B.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The scientific knowledge necessary for engineers to design mobility characteristics into a vehicle does not exist. Mobility engineers in their attempts to fill the need have failed to apply basic scientific methods and principles in a consistent manner. Some of the shortcomings evident in mobility research methods are pointed out. New knowledge obtained from mobility-oriented studies now in progress at the U. S. Army Engineer Waterways Experiment Station is presented to illustrate the importance of basic scientific studies.

KEYWORDS: Mobility; State-of-the-art studies

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THEORY FOR A TOWED WHEEL IN SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

McRae, J. L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1964 (revised September 1964)	35	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1L013001A91A, In-House Laboratory Initiated R&D Projects	Miscellaneous Paper No. 4-626
c. (Further Development of the Load-Flow Theory for Soils) d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 132

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Journal of Terramechanics, vol 1, No. 4, 1964.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A new concept in soil mechanics is sought which will cope with the problem of the behavior of soil when massive displacements are involved, as occurs when a wheel cuts a deep rut in soft material. It is suggested that such movement of soil is more in the nature of a flow phenomenon, and an energy-per-unit-volume concept is hypothesized. The load-sinkage curve is assumed to be of the general form $y = aX^n$; this assumption may have to yield in time to some other more accurate representation, possibly a hyperbolic function. Expressions have been derived for predicting sinkage and towing resistance of rigid wheels in soft soil on the basis of plate penetration tests. These expressions have been modified and extended to cover more complicated performance of pneumatic tires. Experimental verification of the theory in dry desert sand (as found near Yuma, Ariz.) is presented.

KEYWORDS: Mathematical analysis; Soft soils; Soil-wheel interaction; Towed wheels

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3. REPORT TITLE

NORMAL STRESSES AT THE TIRE-SOIL INTERFACE IN YIELDING SOILS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.
Green, A. J.
Murphy, N. R., Jr.

6 REPORT DATE	7a TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1964	31	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-T-0-21701-A-046, Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-629 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 224

10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES Presented at Annual Meeting of the Highway Research Board, Washington, D. C., January 1964; Published in H.R. Record, No. 74, pp.1-18, 1965.	12 SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The U. S. Army Engineer Waterways Experiment Station at Vicksburg, Mississippi, is conducting systematic studies that will provide information on factors which influence vehicle mobility in deformable soils. The ultimate purpose of these studies is to develop rational means of designing military vehicles that will provide specified levels of performance in off-road conditions. A study of the stresses at the interface of a moving pneumatic tire and the medium upon which it travels is one such study. This paper describes the results of tests made to measure the distribution of stresses at the tire-soil interface under some representative test conditions. Two soils, a sand and a clay, carefully placed in a test pit, were used in the program. Each soil was tested at several different levels of strength. Only one tire at one test load was employed, but stresses were measured at several different inflation pressures. Tests were conducted with the wheel powered and with it towed.

KEYWORDS: Laboratory tests; Pneumatic tires; Soft soils; Stresses under wheels

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP
3 REPORT TITLE TERRAIN RECONNAISSANCE WITH ELECTROMAGNETIC SENSORS	
4 DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5 AUTHOR(S) (Last name, first name, initial) Lipscomb, E. B.	

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b. PROJECT NO 1-T-0-21701-A-046, Trafficability and Mobility Research c Task -04, Mobility Terrain Analysis and Symbology d	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-630 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
10 AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11 SUPPLEMENTARY NOTES Published in The Military Engineer, November-December 1963, Vol 55.	12 SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

The Terrain Analyzer Project of the Waterways Experiment Station is aimed at exploiting the electromagnetic spectrum as a means of identifying and quantifying those elements of the terrain that have an effect on military operations. This paper describes the project, which is in its first, or laboratory, phase. Infrared, radar, and gamma-ray studies are discussed.

KEYWORDS: Gamma rays; Infrared rays, Laboratory tests; Radar ; Remote sensing; Soils; Trafficability

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer WAterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified
	2b GROUP

3 REPORT TITLE

THE TERRAIN-VEHICLE PROGRAMS OF THE U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

McRae, J. L.
Knight, S. J.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b. NO OF REFS
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8a CONTRACT OR GRANT NO	9a ORIGINATOR'S REPORT NUMBER(S)
b PROJECT NO 1-T-0-21701-A-046, Trafficability and Mobility Research	Miscellaneous Paper No. 4-638
c Task -03, Mobility Fundamentals and Model Studies	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 218
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10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Published in Journal of Terramechanics, vol 1, No. 1, 1964.	U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

An engineering investigation and development program with the aims of producing means for predicting field performance of military vehicles and furnishing data for use in improving their mobility characteristics has been in progress at the U. S. Army Engineer Waterways Experiment Station since 1945. This paper presents a very brief résumé of the terrain-vehicle research programs of the Waterways Experiment Station.

KEYWORDS: Military vehicles; Mobility; State-of-the-art studies; Traffi.·ability

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

VARIATION IN THE TRAFFICABILITY OF SANDS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Boyd, C. W.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
April 1964	13	8

8a CONTRACT OR GRANT NO b PROJECT NO 1-T-0-21701-A-046, Trafficability and Mobility Research c Task -02, Surface Mobility d	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-647 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Published in The Military Engineer, Vol. 56, No. 372, July-August 1964.	U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

An essential feature of military planning is a knowledge of the trafficability of various soils, i.e. the ability of the soils to support the passage of various military vehicles. In this article, the variation that occurs in the strength or trafficability of sands is described. The sands discussed classify as SP or SW under the Unified Soil Classification System, and are in a "dry-to-moist" condition. Such sands are characteristic of inland deserts and of the portions of beaches of continental island shores not actually undergoing wetting by wave action. The sands discussed do not include those in very wet condition, since the behavior of these sands under vehicular traffic is quite different from that of dry-to-moist sands.

KEYWORDS: Coarse-grained soils; Sands; Soil strength; Trafficability

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified
	2b GROUP

3. REPORT TITLE
TRACKS VERSUS WHEELS IN SOFT SOIL AND SNOW

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5 AUTHOR(S) (Last name, first name, initial)
Freitag, D. R.
Janosi, Z. J.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO	9a ORIGINATOR'S REPORT NUMBER(S)
b PROJECT NO 1-T-0-21701-A-046, Trafficability and Mobility Research	Miscellaneous Paper No. 4-651
c Task -03, Mobility Fundamentals and Model Studies	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 744 222
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10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES Presented at Fourth Meeting of Quadripartite Standing Working Group on Ground Mobility, London, England, 24 June-2 July 1963.	12 SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

Each time a new vehicle is proposed, the choice of running gear can be made only after careful consideration of many factors, the most influential one dictating the use of tracks over wheels being soft-soil performance. Most wheeled vehicles used at the present time have less mobility than tracked vehicles of the same weight. If the mobility of either type of vehicles is to be improved, designs having contact pressure as low as possible must be developed. It was determined that this can be achieved for wheeled vehicles by increasing the number of wheels or by increasing the size of the tires, or by a combination thereof, but that it is more effective to increase the tire size. It was further determined that while light vehicles could be equipped with available tires that would make them competitive with tracks on soft ground, the tracked vehicles have higher pull/weight ratios on firm soil. This paper utilizes the data, techniques, resources, and experience of the Land Locomotion Laboratory, U. S. Army Tank-Automotive Command, and of the Army Mobility Research Branch, Mobility and Environmental Division, Waterways Experiment Station. Techniques of these organizations are described in Appendixes B and A, respectively.

KEYWORDS: Mobility; Soft soils; Soil-track interaction; Soil-wheel interaction; Snow; State-of-the-art studies

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Security Classification

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Security Classification

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP
3. REPORT TITLE A COMPARISON OF QUANTITATIVE VERSUS NONQUANTITATIVE TERRAIN DESCRIPTIVE SYSTEMS FOR MOBILITY ANALYSIS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)	
5. AUTHOR(S) (First name, middle initial, last name) Warren E. Grabau	
6. REPORT DATE May 1964	7a. TOTAL NO OF PAGES 31 / 7b. NO. OF REFS
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-652
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10. DISTRIBUTION STATEMENT Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES Presented at a meeting of the Terrain Sub-Group of the Tripartite Working Group on Ground Mobility, Oxford, England, 24 June 1963	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

The results of vehicle tests have shown that quantitative descriptive and classification systems constitute the most practical basis for terrain evaluation for mobility purposes and that once such systems are available, test sequences can be conducted in known environments which can be extended with nearly complete confidence to other areas of the world which exhibit the same numerical parameters upon analysis. Existing traditional literature on landforms can be associated with quantitative descriptive systems and stored on computer systems for later use in mobility prediction systems. Three basic programs are being conducted at the Waterways Experiment Station in the field of mobility research: (a) the development of detailed quantitative systems for describing and classifying environments, (b) the testing of the responses of vehicles to known environments, classified both quantitatively and traditionally, and (c) the correlation of traditional classifications with quantitative classifications.

KEYWORDS: Mobility; Terrain analysis; Terrain classification; Terrain factors

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1. ORIGINATING ACTIVITY (Corporate author) U.S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
REPORT OF SECOND MEETING OF ARPA ADVISORY COMMITTEE ON MOBILITY ENVIRONMENTAL RESEARCH STUDY (24-26 February 1964, Vicksburg, Mississippi)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Progress report to February 1964

5. AUTHOR(S) (First name, middle initial, last name)
Not applicable

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. Project MERS c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-670 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 478 994

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Advanced Research Projects Agency

13. ABSTRACT

This report consists of 18 papers presented at the Advisory Committee meeting, summaries of important discussions and questions relative to the various papers, the Committee's conclusions and recommendations, and a report of an Ad Hoc Working Group recommended by the Committee to examine the applicability of an airborne profilometer to obtain terrain profiles. The papers included reports on WES studies related to Project MERS, review of project history, conclusions and recommendations of the first Advisory Committee meeting held at Bethesda, Maryland, on 7-9 November 1962, accomplishments on Project MERS tasks since the first committee meeting, Marsh Screw Amphibian tests conducted by WES, Project MERS plans for the next 12 months, and funding status and requirements for fiscal year 1965.

KEYWORDS: Meetings; Mobility; State-of-the-art studies; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	Unclassified 2b. GROUP

3. REPORT TITLE

RETENTION OF DETAIL IN MAP GENERALIZATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau and Eugene E. Addor

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Paper prepared for presentation at 1964 Regional Convention of the American Congress on Surveying & Mapping, Kansas City, Mo., 24-26 Sep 1964	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The distribution of things in any approximately homogeneous population can be adequately described by a sample which is coincident with a minimal area called the "structural cell." The smallest area which can be depicted on any map is a function of the map scale and is called a "mapping cell." Areas of lesser extent than the mapping cell cannot be shown and are therefore merged into the map unit of greater occupance, resulting in a map unit characterized in the legend as a single population, but in fact representing areas composed of two or more populations. Such a map unit has a "reliability" of substantially less than 100 percent. Retention of detail with scale reduction depends upon recognition of the scalar relationships between the mapping cell and the structural cells of the populations being mapped. The boundaries between the units are generalized according to a set of prescribed rules, and a legend is designed consisting of diagrammatic representations of "unit areas" in which the relative proportions, as well as the schematic positional relations of all populations comprising the generalized map unit are identified.

KEYWORDS: Terrain analysis; Terrain mapping

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE VICKSBURG MOBILITY EXERCISE A; VEHICLE ANALYSIS FOR REMOTE-AREA OPERATION	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (Last name, first name, initial) Knight, S. J.	
6. REPORT DATE February 1965	7a. TOTAL NO. OF PAGES 167 / 7b. NO. OF REFS 26
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. ;-702 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 613 ·66
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

During the period 21-25 September 1964, a group of specialists met to consider in a quantitative way the various elements of the surface mobility problem and to devise an approach toward its solution. The problem is discussed in Appendix A. The participants in the exercise are listed in Appendixes B and D and the pre-conference outline is included as Appendix C. During the exercise, three vehicle concepts, two wheeled (8x8 and 10x10) and one tracked, were designed on the basis of existing empirical and quasi-theoretical knowledge and in the light of worldwide occurrence of soil conditions. A plan of tests was designed that not only will test the validity of the design techniques employed, but also will serve as a model for future exercises in mobility. In each phase of the analysis, emphasis was directed toward the soft-soil aspect of the mobility problem. However, a plan incorporating tests of other environmental factors also was suggested and is included as Appendix E; a study of roadway preparation requirements is included as Appendix F.

KEYWORDS: Meetings; Mobility; Vehicle design; [Mobility Exercise A]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

TRAFFICABILITY OF SNOW IN ARCTIC AND SUBARCTIC REGIONS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name first name, initial)

Schreiner, B. G.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b PROJECT NO 1-T-0-21701-A-046, Trafficability and Mobility Research c Task No. -02, Surface Mobility d.	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-713 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 745 150

10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Presented at the International Society for Terrain-Vehicle Systems, Houghton, Michigan, 9-10 February 1965	U. S. Army Materiel Command Washington, D. C.

13 ABSTRACT

Two general categories of snow were considered--the deep, permanent Greenland ice-cap snow and the "temporary" (subarctic) snow of Canada and mountain regions of the United States. Test results indicated that, generally, all military tracked vehicles could travel over the level, permanently covered, deep snow areas of the Greenland ice cap and over the subarctic snow when it was less than about 36 in. deep. Maximum drawbar pulls on ice-cap snow were found to vary in a narrow range, from about 35 to 45 percent of the gross weight of the vehicle; while on subarctic snow, maximum drawbar pulls depended significantly upon the depth of the snow.

KEYWORDS: Arctic regions; Field tests; Military vehicles; Mobility; Snow; Snow trafficability; Subarctic regions; [Canada; Greenland]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE
MOBILITY ENVIRONMENTAL RESEARCH STUDY: SELECTION AND DESCRIPTION OF TEST AREAS U. S. MILITARY RESERVATIONS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Report 1 of a series

5 AUTHOR(S) (Last name, first name, initial)
Woods, Harry K.
Shamburger, John H.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO	9a ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Miscellaneous Paper No. 4-726
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10 AVAILABILITY, LIMITATION NOTICES
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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Service Agent: Army Materiel Command Washington, D. C.	Office, Secretary of Defense Advanced Research Projects Agency Washington, D. C.

13 ABSTRACT

One of the tasks in connection with obstacles studies to develop the capability to predict in quantitative terms the effects of terrain obstacles on cross-country performance of ground vehicles was entitled "Proof Tests of Ground Mobility in the U. S." This report is concerned with the first phase of the proof tests, selection and preliminary description of test areas selected for examination on 15 military reservations. The terrain factors considered as having an obstacle-producing effect on vehicle performance were vegetation, surface microgeometry, and surface macrogeometry (principally slope). Areas within the 15 reservations meeting established criteria were tentatively located through an airphoto interpretation study. The terrain characteristics were measured at the selected sites during ground reconnaissances. These data were analyzed and the reservations were categorized according to the availability of sites for conducting single- and multiple-factor tests. Camp Lejeune, N. C., Camp A. P. Hill, Va., and Eglin AFB, Fla., offer more areas suitable for conducting single-factor tests than the other reservations. A variety of combinations of slopes and stem spacing desirable for conducting multiple-factor tests is present at Camp A. P. Hill, Va., Camp Pickett, Va., and Quantico Marine Schools, Va.

KEYWORDS: Military bases; Temperate regions; Terrain analysis; Terrain factors; Terrain mapping

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP

3. REPORT TITLE

TESTS TO EVALUATE THE MOBILITY OF JIGER AND FISHER VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Meyer, M. P.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The tests reported herein were conducted to measure and compare the mobility performance of the Jiger and Fisher vehicles in muskeg terrain. The tests were conducted by personnel of the Organic and Associated Terrains Research Unit of McMaster University, Hamilton, Ontario, under contract to the Directorate of Weapons Research, Defence Research Board, Canada. WES and the Land Locomotion Laboratory were invited to send observers.

KEYWORDS: Field tests; Light utility vehicles; Mobility; Muskeg; Trafficability; [Fisher vehicle; Jiger vehicle; Parry Sound, Ontario, Canada]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STATISTICAL EVALUATION OF CONE-PENETRATION-TEST DATA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. K. Poplin

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c. Subtask 13.010	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Defense Atomic Support Agency and Office, Chief of Engineers

13. ABSTRACT

An investigation was conducted using a typical laboratory specimen and 12' penetrations were made with a 1/2-in.-diam 30-deg cone penetrometer. The penetrations were made at 6-in. spacings in various patterns to study the effect of penetration sequence, interaction, and boundaries. In addition, 25 density samples were taken from the specimen and a single plate-bearing test using a 6-in.-square plate was conducted. The cone-penetration-resistance data and density data were subjected to standard statistical analysis. Differences in mean values from different zones in the specimen were compared to determine if real differences existed and were not the result of random scatter in data. Density data indicated that the specimen was uniform within the capabilities of determination but that variations not accountable as random scatter in cone-penetration resistance existed between various points in the specimen. Cone-penetration resistance was found to be adequate for evaluating uniformity provided sufficient observations were made. Generally, about eight penetrations were required to yield a mean value which could be expected to be within 6 percent of the true mean value.

KEYWORDS: Cone penetration tests; Laboratory tests; Penetration resistance (Soils); Plate bearing tests; Sands; Soil density; Soil penetration tests; Soil property variations; Soil strength

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

CENTER-LINE DEFLECTION OF PNEUMATIC TIRES MOVING IN DRY SAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.
Smith, M. E.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-750 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 7-5 15?

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Journal of Terramechanics, vol 3, No. 1, 1966.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Tire deflection data were studied from tests performed in the single-wheel test facilities at the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. The tests were performed with a smooth 11.00-20, 12-PR tubular tire moving under a 3000-lb load in mortar sand of various strengths and a smooth 9.00-14,2-PR tubeless tire moving under an 890-lb load in Yuma sand of various strengths. Plots are presented of the path of a point on the center line of the tires relative to a moving and a fixed frame of reference. Representative plots are included to show the effect of slip, soil strength, and inflation pressure on the path and to compare the paths of a point on towed and powered tires.

KEYWORDS: Laboratory tests; Pneumatic tires; Sands; Tire deflection

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TRAFFICABILITY TESTS WITH THE MARSH SCREW AMPHIBIAN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Knight, S. J.
Rush, E. S.
Stinson, B. G.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1965	30	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046 Trafficability and Mobility Research c. Task No. -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-751 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 745 153

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Journal of Terramechanics, Vol 2, No. 4, 1965.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A program of field tests was conducted with the Marsh Screw Amphibian to evaluate its performance on a range of soil conditions. Performance was expressed in terms of ability to travel 50 passes in the same path, maneuverability, speed, drawbar pull, and slope-climbing ability. Soil conditions were described in terms of soil type, moisture content, density, and cone index. Relations between vehicle performance and soil condition are presented.

KEYWORDS: Buoyant screw vehicles; Field tests; Fine grained soils; Mobility; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE A STUDY OF THE EFFECTS OF WET SURFACE SOIL CONDITIONS ON THE PERFORMANCE OF A SINGLE WHEEL	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (Last name, first name, initial) Smith, J. L.	

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO c. ARPA Order No. 400 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-757 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 745 154
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES Published in Journal of Terramechanics, vol 3, No. 2, 1966.	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Washington, D. C. 20301; Service Agent: U. S. Army Materiel Command

13. ABSTRACT Tests were conducted to determine the effects of wet surface soil conditions on the performance of pneumatic tires. Two fine-grained soils were used: one highly plastic and one only slightly plastic. Surface soil conditions were of three types: "as compacted," flooded and drained, flooded and undrained. Most tests were conducted on one soil (heavy clay), one tire size (6.00-16), and one deflection (35 percent). Four tread conditions were tested: a smooth tire, a directional tread, a nondirectional tread, and a smooth tire with traction aid. It was found that for a given wheel load the loss of pull due to flooding is a constant for each tread pattern. Further, it was found that a peak performance was attained at a specific load, regardless of tread pattern or soil condition. It was also determined that repetitive traffic had no effect on pull through five passes in the "as compacted" condition; but for the flooded soil, the pull increased with traffic in the drained condition and decreased with traffic in the undrained condition. The level of performance depended to some extent on the duration of flooding. The lowest pulls were attained when the flooding period was very brief and the soil strength was high.

KEYWORDS: Fine grained soils; Flooded soils; Laboratory tests; Pneumatic tires; Soil-wheel interaction; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

MECHANICS OF WHEELS ON SOFT SOILS; A METHOD FOR PRESENTING TEST RESULTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Leflaive, E.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
December 1965	21	3

8a. CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research	Miscellaneous Paper No. 4-758
c. Task -03, Mobility Fundamentals and Model Studies	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 746 399
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Journal of Terramechanics vol 3, No. 1, 1966.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A method is presented for studying the results of tests with wheels in soils. The first part of the paper emphasizes the need for a framework to describe observed facts, and in the next part, a method is developed to provide this framework. The method considers the work of the pull developed by the test wheel as the difference between energy input and energy dissipation. The parameters used to represent these energies are explained relative to the theoretical case of a rigid wheel on a hard surface. This reference condition also is used to distinguish the particular features of rolling motion on deformable soils.

KEYWORDS: Soft soils; Soil-wheel interaction; Trafficability; Wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE TESTS WITH THE CH-47A CHINOOK HELICOPTER IN SOFT CLAY SOIL	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (Last name, first name, initial) Rush, E. S.	
6. REPORT DATE January 1966	7a. TOTAL NO OF PAGES: 42 — 7b. NO OF REFS: 2
8a. CONTRACT OR GRANT NO. b. PROJECT NO 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task 02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-766 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 627 377
10. AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The primary purpose of the test program reported herein was to determine quantitatively the performance of the CH-47A Chinook helicopter in soft soils. Tests were conducted at three different locations on a range of soil strengths and at three different payloads. A total of 15 landings were made on 27 and 28 May 1965 near Vicksburg, Miss. Subsequent tests were conducted at Aberdeen Proving Ground, Md., from 21 to 24 June 1965. The Aberdeen Proving Ground tests are discussed briefly in Appendix A.

It was concluded that (a) the Chinook has adequate power for lift-off from most soft soil conditions, (b) a relation exists between sinkage of landing gear assembly into a soil and the ratio of bearing pressure to cone index, and (c) the presently designed cargo ramp will allow a cargo space entrance height of 72 in. only when the helicopter landing gear sinkage is about 12 in. or less.

KEYWORDS: Helicopter landing zones; Soft soils; Soil strength; Trafficability; [Aberdeen Proving Ground, Md.; Chinook helicopter; Vicksburg, Miss.]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EFFECTS OF AIR SURCHARGE ON THE BEARING CAPACITY OF SOFT, COHESIVE SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Lanz, Larry J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-767 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 630 804

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A test program was conducted to determine the effects of air surcharge on the bearing capacity of soft, cohesive soils. The test soils were of two types, fat clay and silt. The penetration resistance of a 3-sq-in. circular plate was selected as the measure of bearing capacity to be used. Cone penetration tests were performed also for control purposes. The plate penetration tests were conducted using air-surcharge pressures of 0, 1, and 5 psi.

Test results show that the bearing capacity of the highly saturated, cohesive soils used in this study was not altered in any significant way by the application of air-surcharge pressures as high as 5 psi. As a corollary, it was found that cone index was linearly related to plate bearing pressure in each soil type, regardless of the air surcharge applied.

KEYWORDS: Air surcharge pressure, Bearing capacity; Fine grained soils; Soft soils

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

TRAFFIC TESTS TO DETERMINE THE BENEFITS OF VEGETATION IN INCREASING TRAFFIC COVERAGES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

L. M. Womack

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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	Miscellaneous Paper No. 4-769
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Air Force Cambridge Research Laboratories L. G. Hancom Field Cambridge, Massachusetts

13. ABSTRACT

This report describes the accelerated traffic tests conducted with a test load and tire pressure selected to cause failure in an unsurfaced test section at a low-coverage level (less than 100 coverages) to determine the adequacy of present criteria for predicting low-coverage levels and to determine if there is added benefit in terms of increased traffic coverages from heavily sodded areas as opposed to areas which are clear of vegetation and root structure. Selection of the load and tire pressure was made from current criteria for the CBR required for operation of aircraft on unsurfaced soils and was based on the average CBR of the 0- to 6-in. depth. Results of the tests indicate that for conditions of these tests present criteria are somewhat conservative for predicting low-coverage levels of traffic. Although there was some benefit gained from the sod in one test item, there were not sufficient data to conclude that sodded areas will sustain substantially higher intensities of traffic. It is recommended that additional tests using other wheel loads and tire pressures be conducted to develop criteria for predicting low-coverage levels of traffic on unsurfaced areas.

KEYWORDS: Accelerated traffic tests; Soil strength; Trafficability; Unsurfaced airfields; Vegetative cover

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

REPORT OF CONFERENCE OF THE BOARD OF CONSULTANTS ON REMOTE TERRAIN ANALYSIS BY ELECTROMAGNETIC MEANS; WATERWAYS EXPERIMENT STATION, 18-19 NOVEMBER 1965

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Not applicable

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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c. Task -04, Mobility Terrain Analysis and Symbology	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	AD 747 095

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A conference of the Board of Consultants on Remote Terrain Analysis by Electromagnetic Means was held at the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi, on 18-19 November 1965. Only summaries of the technical papers presented are given herein; complete texts of these presentations of test programs and results to date will be published as WES technical reports under the general title Terrain Analysis by Electromagnetic Means. Exhibit 1 is the program for the meeting, and Exhibit 2 is a list of attendants. Exhibit 3 describes proposed future plans. Exhibit 4 presents the report prepared by the Board of Consultants at the conclusion of the conference.

KEYWORDS: Electromagnetic radiation; Meetings; Remote sensing; Soils; State-of-the-art studies; Terrain analysis; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author): [illegible] Engineer Waterways Experiment Station, [illegible], Miss.

2a. REPORT SECURITY CLASSIFICATION: [illegible]

2b. GROUP

3. REPORT TITLE: [illegible]

4. DESCRIPTIVE NOTES (Type of report and inclusive dates): Final report

5. AUTHOR(S) (Last name, first name, initial): [illegible]

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research

c. Task -04, Mobility Terrain Analysis and Symbology

d.

9a. ORIGINATOR'S REPORT NUMBER(S): Miscellaneous Paper No. 4-822

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report): AD 747 096

10. AVAILABILITY LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES: Published in Proceedings of the Fourth Symposium on Remote Sensing of Environment at Univ. of Mich., Ann Arbor, Mich., 12-14 Apr 66

12. SPONSORING MILITARY ACTIVITY: U. S. Army Materiel Command, Washington, D. C. [illegible]

13. ABSTRACT

Laboratory studies have been conducted at the Waterways Experiment Station to determine the effects of soil layering on the quantity of reflected energy measured from terrain. The results of this study indicate that reflections from subsurface interfaces can have a drastic influence on the quantity of energy measured and that standard monochromatic pulsed-radar systems are not suitable for measuring subsurface soil conditions. Systems employing swept-frequency techniques are needed to allow direct measurement of electrical properties of the soils. These properties then can be correlated with the thickness of the upper layer and the moisture content of the soil.

Besides soil layers, such factors as soil conductivity and vegetation determine the usable wavelength region. The effects of each of these are discussed and examples of several soil-layering profiles that might be encountered in natural terrain are given. The limits to which the layering profiles of the soils influence the return energy are illustrated. These limits are determined by the thicknesses of the layers and the electrical properties of the soil comprising each layer.

KEYWORDS: Laboratory tests; Radio waves; Remote sensing; Soil stratification; Soils

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1 ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a REPORT SECURITY CLASSIFICATION
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2b GROUP

3 REPORT TITLE
[illegible] INVESTIGATIONS OF THE [illegible] FOR REMOTE [illegible] OF SOIL TRAFFICABILITY [illegible]

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report.

5 AUTHOR(S) (Last name, first name, initial)
Williamson, Albert N., Jr.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO

b PROJECT NO 1-V-0-21701-A-046, Trafficability and Mobility Research
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9a ORIGINATOR'S REPORT NUMBER(S)
Miscellaneous Paper No. 4-823

9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
AD 747 097

10 AVAILABILITY/LIMITATION NOTICES
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11 SUPPLEMENTARY NOTES Published in Proceedings of the Fourth Symposium on Remote Sensing of Environment held at the Univ of Mich., Ann Arbor, Mich., Apr 1966.

12 SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13 ABSTRACT

Gamma radiation from soil samples was measured, and the results were analyzed to evaluate the use of gamma rays in remotely determining soil parameters useful in estimating trafficability. Gamma-ray spectra were obtained from representative samples of sand, silt, and clay placed in a low-background inclosure. Photopeak counting rates and photopeak ratios of thorium, uranium, potassium were considered in the analysis. Results indicated that photopeak counts of the radioisotopes of primary interest were proportional to moisture content of the soil samples, but ratios of the photopeaks were nearly independent of moisture content, although different for each soil tested.

Gamma-ray measurements were also made on soil samples obtained from all 50 states in an attempt to correlate the ratios of their photopeaks of thorium, uranium, and potassium with soil type and other morphological, genetic, and physical-chemical characteristics of the soils.

KEYWORDS: Gamma rays; Laboratory tests; Remote sensing; Soils, Trafficability

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

DEVELOPMENT OF A FORMULA FOR TOWING RESISTANCE FOR A WHEEL IN SOFT SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

McRae, J. L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1966	18	1

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1L013001A91A, In-House Laboratory Initiated R&D Projects c. (Further Development of the Load-Flow Theory for Soils) d.	Miscellaneous Paper No. 4-828
	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 746 400

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Proceedings 1966 Army Science Conference, West Point, N. Y., Vol II	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

The dimensional analysis and the empirical correlation achieved in developing a dimensionally correct formula for approximating the towing resistance for either a rigid or a pneumatic-tired wheel are presented. A method, called the moving chord concept, for handling the geometry of the complex phenomenon relating to the configuration of a pneumatic tire in soft soil (based on experimental evidence) is presented. The formula that is developed satisfied quite effectively a wide range of tire sizes, wheel loads, and tire deflections in two extremes of soil type, namely cohesionless dry Yuma desert sand and highly plastic Louisiana buckshot clay.

The developed formula is $P_T = 0.85\ W(z/\ell)^{0.77}$ where P_T is towing force, W is vertical load, z is sinkage, and ℓ is the horizontal projection of the center line of tire contact area in the direction of travel.

KEYWORDS: Dimensional analysis; Mobility numbers; Motion resistance; Pneumatic tires; Rigid wheels; Soft soils; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a REPORT SECURITY CLASSIFICATION Unclassified
	2b GROUP

3. REPORT TITLE

COMPARISON OF GROUND MOBILITY CHARACTERISTICS OF LAND-MARINE INTERFACES OF FLORIDA AND THAILAND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)

Garrett, E. E.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1-V-0-25001-A-131, Military Evaluation of Geographic c. Areas.	Miscellaneous Paper No. 4-829
d. ARPA Order No. 400	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 800 075

10. AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
	Advanced Research Projects Agency and U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A semiquantitative system for describing the pertinent characteristics of land-marine interfaces with regard to ground mobility is developed and presented herein. The description involves the subjective identification of characteristic zones of the interface, and the measurement or designation of significant properties of those zones. The range of values or designation exhibited by each property is divided into suitable classes, and each class is assigned a code number. A total of 27 coastal sites in northwest and west central Florida and the Florida Keys and 14 coastal sites in Thailand are evaluated according to the newly developed system. A comparison of the Florida and Thailand coastal sites based on relative frequencies of occurrence of the range of values of each property is presented, and areas that may be expected to show some degree of similarity are identified. General conclusions are: (a) land-marine interfaces on the Gulf of Siam have characteristics that are closely approximated on the northwest and west central coasts of Florida, (b) the land-marine interfaces on these shores exhibit a close analogy when compared with regard to structural zones, and (c) land-marine interfaces of the two areas not within a gulf environment (i.e. those not protected from oceanic wave attack) exhibit divergent characteristics.

KEYWORDS: Beach trafficability; Coasts; Land-water interface; Mobility; Terrain analogs; Terrain factors; Tropical regions; [Florida; Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
A DIMENSIONAL ANALYSIS OF THE PERFORMANCE OF PNEUMATIC TIRES ON CLAY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Freitag, D. R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046 Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-835 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES Published in Journal of Terramechanics, Vol 3, No. 3, 1966.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT
Treadless pneumatic tires were tested in specially prepared wet clay. Horizontal and vertical forces, torque, slip, and sinkage were measured. The test variables included tire width and diameter, tire deflection, and the load on the tire. The soil strength was varied over the full practicable range. A dimensional analysis of the tire-soil systems tested yielded three principal independent Pi terms: the shape number $\frac{b}{d}$, the deflection number $\frac{\delta}{h}$, and the clay loading number $\frac{Cd^2}{W}$. Four dependent Pi terms--the pull number $\frac{P}{W}$, the sinkage number $\frac{z}{d}$, the torque number $\frac{Q}{dW}$, and the towed force number $\frac{P_T}{W}$--were used as measures of tire performance. The experimental results showed that the consistency of the soil could be evaluated, and that true scaled systems could be achieved. A single term was developed that combined all of the independent parameters and this term was shown to be related to the dependent parameters. Curves delineating the following relations were developed:

$$\frac{P}{W}, \frac{z}{d}, \frac{Q}{dW}, \frac{P_T}{W} = f\left[\frac{Cdb}{W}\left(\frac{\delta}{h}\right)^{1/2}\right]$$

KEYWORDS: Clays; Dimensional analysis; Laboratory tests; Mobility numbers; Pneumatic tires; Soil-wheel interaction

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

A DIMENSIONAL ANALYSIS OF THE PERFORMANCE OF PNEUMATIC TIRES ON SAND

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5 AUTHOR(S) (Last name, first name, initial)

Freitag, D. R.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b. PROJECT NO 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -03, Mobility Fundamentals and Model Studies d.	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-836 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 716 341

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES Presented at 59th Annual Meeting of the ASAE at Amherst, Mass., 26-29 June 1966, Paper 66-128; Trans. of ASAE, Vol II, No. 5, 1968.	12 SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

Several sizes of treadless pneumatic tires were tested in specially prepared dry sand under a variety of test loads and inflation pressures. The results showed that the pertinent soil properties could be evaluated and that the tire-soil system could be scaled.

KEYWORDS: Dimensional analysis; Laboratory tests; Mobility numbers; Pneumatic tires; Sands; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

VARIATION IN TRAFFICABILITY OF FOUR LOESS SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (Last name, first name, initial)

Bassett, John R.
McDaniel, Alvin R.
Knight, Sterling J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -02, Surface Mobility d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-838 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 800 144

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES Published in SSSA Proceedings, Vol 31, No. 1, Jan-Feb 1967, titled "Trafficability of Four Loess Soils."	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Grain-size distribution, Atterberg limits, organic matter content, dry unit weight, field moisture content, and strength of the 6- to 12-in. soil layer were measured once during the wet season at 65 test sites located in northeast Louisiana and southeast Arkansas. Soils were modal silt loams of four related series: Loring, Grenada, Calloway, and Henry. Series descriptions and typical soil profiles of the soil series are given in Appendix A. Regression analysis was used to relate cone index, remolding index, and rating cone index, respectively, to moisture content for all series, individually and grouped. Differences between individual series regressions were not significant (0.05 level). The group equation for rating cone index was significant (0.01 level) and explained 66 percent of the variation in rating cone index associated with changes in moisture content. To illustrate use of the results, the group equation for rating cone index was used to estimate the trafficability of a forested area for a TD-9 tractor for each day of a 16-month period. The estimates agreed closely with observed field conditions, suggesting that the four series can be combined for trafficability classification.

KEYWORDS: Field tests; Loess; Soil property relations; Soil property variations; Trafficability; [Arkansas; Louisiana]

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1. ORIGINATING ACTIVITY (Corporate author) J. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

CONCEPTS FOR VEHICLES FOR OFF-ROAD USE IN REMOTE AREAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

Rula, Adam A.
Freitag, Dean R.
Knight, Sterling J.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-854
b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Presented at the Society of Automotive Engineers, Inc., Detroit, Michigan, 5-13 January 1967; Paper No. 670171	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A group of specialists was assembled at the U. S. Army Engineer Waterways Experiment Station (WES) to consider quantitatively the various elements of the entire vehicle mobility problem and to suggest an approach for achieving a substantial degree of solution. One specific purpose of the meeting, and the one that is the subject of this paper, was to design a number of vehicles capable of operating in remote areas of the world where extremely soft soil conditions predominate.

Methods of design based on research studies at the WES and at the Land Locomotion Laboratory, U. S. Army Tank-Automotive Center, were employed to specify tractive component characteristics that would yield the desired soft soil performance. The final concepts that were evolved reflect chiefly the soft soil requirements, but other factors such as obstacle performance were also kept in mind. This paper describes the application of the design methods and presents the two wheeled-vehicle concepts and the one tracked-vehicle concept that were evolved to satisfy the basic assumptions.

KEYWORDS: Meetings; Mobility; Vehicle design

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TERRAIN EVALUATION OF A PORTION OF THE FORT GREELY AUTOMOTIVE TEST COURSE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Shamburger, John H.
Kolb, Charles R.
Woods, Harry K.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
December 1966	67	7

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO U. S. Army Arctic Test Center Order No. 5016-1	Miscellaneous Paper No. 3-861
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10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Arctic Test Center Fort Greely, Alaska

13. ABSTRACT

A method for classifying and mapping terrain features pertinent to off-road mobility in selected temperate, tropical, and desert areas was applied to subarctic terrain in this study. The area involved borders the Automotive Test Course of the U. S. Army Arctic Test Center at Fort Greely, Alaska, and is roughly 2000 ft wide and 15 miles long. Conditions mapped were those prevalent during the late summer. The classification and mapping method proved satisfactory with only minor modifications. Terrain factors unique to cold regions which require additional research before they can be properly classified and mapped for mobility test purposes include depth of thaw, snow depth, snow type, ice thickness, and stream turbidity.

KEYWORDS: Military bases; Offroad mobility; Subarctic regions; Terrain analysis; Terrain classification; Terrain mapping; [Fort Greely, Alaska]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
THEORY FOR PREDICTING PERFORMANCE OF A WHEEL IN SOFT SOIL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
McRae, J. L.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1967	82	0

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-870
b. PROJECT NO. 4A013001A91D, In-House Laboratory Independent Research c. Program, Item I, Further Development of the Load-Flow Theory for Soils d.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Assistant Secretary of the Army (R&D)

13. ABSTRACT
This paper presents the results of the development of semiempirical formulas for the towed force and for the maximum drawbar pull of pneumatic-tired wheels in soft soils. It assumes that the depth of sinkage of the wheel is known, and it utilizes an "effective shear strength" for the soil based upon an empirical correlation with the WES cone index. It includes an appendix that presents a mathematical theory for load-penetration relations for some idealized materials.

KEYWORDS: Mathematical analysis; Performance predictions, Pneumatic tires; Soft soils; Soil-wheel interaction; Tire performance

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

TRAFFICABILITY TESTS IN FINE-GRAINED SOILS WITH TWO VEHICLES WITH 9- TO 10-TON WHEEL LOADS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5 AUTHOR(S) (Last name, first name, initial)

Rush, Edgar S.
Temple, Robert G.

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b. PROJECT NO 1-V-0-21701-A-046, Trafficability and Mobility Research c Task -02, Surface Mobility d	9a ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-879 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 811 217

10 AVAILABILITY/LIMITATION NOTICES

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11 SUPPLEMENTARY NOTES Paper published in Journal of Terramechanics, vol 4, No. 1 (1967), pp 31-48.	12 SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

Trafficability tests were conducted in fine-grained soils with two vehicles with 9- to 10-ton wheel loads, the LeTourneau Electric Digger, Model L-28, and the LeTourneau Log Stacker, Model F. Forty-one "go-no go" tests were performed on three different soils classified CH, CH/CL, and CL/ML. Results showed that the minimum soil strength requirements (vehicle cone indexes) for 50 passes of the Electric Digger and the Log Stacker were 185 and 150, respectively. A revised mobility index formula, discussed in Appendix A, proved to be more reliable than the original mobility index formula for computing vehicle cone indexes of the two vehicles. When the Digger's tire inflation pressure was reduced from 75 to 27 psi, the experimental VCI was reduced from 185 to 160. Limited data suggest that the development of trafficability criteria for less than 10 passes of a vehicle will require a careful analysis of the rate of remolding of the soil by vehicle wheels or tracks and of the relative influence of various soil layers.

KEYWORDS: Field tests; Fine-grained soils; Forestry vehicles, Mobility; Trafficability; Vehicle cone index; [LeTourneau Electric Digger; LeTourneau Log Stacker]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

REPORT OF CONFERENCE ON SOIL TRAFFICABILITY PREDICTION, U. S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION, 29-30 NOVEMBER 1966

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Not applicable

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release: distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This report summarizes the discussions of a meeting held at the U. S. Army Engineer Waterways Experiment Station on 29-30 November 1966 to review the progress of studies related to soil trafficability prediction conducted since the last consultants meeting in 1958 and to afford the consultants an opportunity to comment on problem areas and make recommendations for future research. Summaries were presented on studies as follows: methods of soil moisture prediction for trafficability purposes (C. A. Carlson); effects and deficiencies of factors used in WES soil moisture prediction system (A. R. McDanial); a tentative soil strength prediction system; influence of water tables on soil moisture and soil strength (J. G. Collins); influence of soil variability on soil moisture and soil strength predictions (H. D. Molthan); comparison of soil moisture prediction factors for temperate and tropical climates (M. H. Smith); predicting and portraying soil moisture on an areal basis in Costa Rica (A. R. McDanial); and soil trafficability classification scheme (M. P. Meyer).

KEYWORDS: Meetings; Soil moisture prediction; Soil strength prediction; State-of-the-art studies; Trafficability; Trafficability prediction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION: Unclassified 2b. GROUP

3. REPORT TITLE

BUMPS AND GRINDS - STUDIES IN BODY MOTIONS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

W. G. Shockley

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. ARPA, DRAC, Order No. 400 AMC R&D 1-V-0-25001-A-131 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S): Miscellaneous Paper No. 4-893 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report): AD 747 098

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at Fifth Meeting of the Quadripartite Standing Working Group on Ground Mobility, Kingston and Parry Sound, Ontario, Canada, 9-19 Aug 1965	U. S. Army Materiel Command & the Advanced Research Projects Agency, Directorate of Remote Area Conflict

13. ABSTRACT

This report summarizes two WES contract studies in vehicle ride dynamics, each with a different approach to the problem of describing and defining the dynamic response characteristics. One study, conducted by Chrysler Corporation, is reported in "A Study of the Vehicle Ride Dynamics Aspects of Ground Mobility," WES Contract Report No. 3-114, Vols. 1 and 2, Mar 1965 and Vols. 3 and 4, Apr 1965. The other, conducted by FMC Corporation, is reported in "A Computer Analysis of Vehicle Dynamics While Traversing Hard Surface Terrain Profiles," WES Contract Report No. 3-155, Feb 1966. The dual approach reveals two separate and distinct problems. One problem is to define force and motion in a suspension system in such a way that the relations can be used to improve the design of suspension systems. This the FMC Corporation mathematical model appears to do. The other problem is to describe motion in objective terms in such a way that the mathematically derived terms correlate directly with human response. While a satisfactory solution to this problem has not yet been achieved, it appears that the Chrysler Corporation statistical procedure will be suitable for this purpose.

KEYWORDS: Computerized models; Mathematical models; Mobility; Ride dynamics, Vibration effects (Vehicles)

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

AERIAL CONE PENETROMETER FOR MEASURING THE TRAFFICABILITY OF SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Sterling J. Knight

6. REPORT DATE May 1967	7a. TOTAL NO. OF PAGES 12	7b. NO. OF REFS 7

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Published in The Military Engineer, Vol 59, No. 390, Jul-Aug 1967.	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

The aerial cone penetrometer is a simple device for the determination of soil trafficability for a remote source. It has a number of possible military applications and would require only a modest amount of additional development to make it a practical Army tool. The credibility of the aerial cone penetrometer is best exemplified by the smooth and reproducible relations that exist between soil strength (as measured in terms of cone index) and depth of penetration of the aerial penetrometer (at a constant contact velocity).

KEYWORDS: Aerial cone penetrometers; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TRAFFICABILITY TESTS WITH A TWO-WHEEL-DRIVE INDUSTRIAL TRACTOR

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Edgar S. Rush
Beryl G. Stinson

6. REPORT DATE
August 1967

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8a. CONTRACT OR GRANT NO.

b. PROJECT NO. 1-V-0-21701-A-046,
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9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES
Presented ASAE meeting, Detroit, Mich., 12-15 Dec 967, Paper No. 67-607, Transac. ASAE, Vol 11, No. 6, 1968

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

Trafficability tests (12 self-propelled and 4 maximum drawbar pull) were conducted in a heavy clay soil to determine performance capabilities of a small, two-wheel-drive industrial tractor. The minimum soil strength required for 50 passes of the vehicle, or the vehicle cone index (VCI), was determined from these tests to be 49. The VCI computed by a revised (March 1967) mobility index formula was 51. The one-pass VCI determined from the self-propelled and limited maximum-drawbar-pull tests was 27, or 55 percent of the experimental 50-pass VCI.

KEYWORDS: Clays; Field tests; Fine grained soils; Mobility; Tractors; Trafficability; Vehicle cone index; Wheeled vehicles

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A SUGGESTED PROCEDURE FOR THE SELECTION AND DESCRIPTION OF REFERENCE TEST AREAS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
August 1967	27	10

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-25001-A-131 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-921 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 658 659

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command

13. ABSTRACT A procedure is presented for the selection and description of reference test areas (RTA's) in which the Quadripartite nations can test and evaluate their military vehicles. The procedure consists of four phases:

a. Selection of areas of national interest by each of the Quadripartite nations.
b. Identification and description of the facets comprising the areas of national interest.
c. Selection of RTA's within each member nation in a location which exhibits the maximum number of facet types as found in the areas of national interest.
d. Description of all RTA's in terms of landscape pattern, facet and subfacet composition, factor value ranges characterizing each facet and subfacet, and factor values mapped independently.

The factor value descriptions must be in terms of ranges of values for those factors which significantly affect vehicle performance. The factors are hypothesized to be:

a. Soil factors: soil mass strength, soil surface strength.
b. Vertical obstacles: macroslope, step height, width, length, spacing, approach angle, soil mass strength.
c. Lateral obstacles: spacing, stem spread, branching height, clustering index.
d. Longitudinal obstacles: spacing, stem diameter, bending strength, clustering, soil mass strength.
e. Water-land interface: depth, approach angle, current velocity.

KEYWORDS: Mobility; Reference test areas; Site selection; Terrain analysis; Terrain factors

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

FLOTATION REQUIREMENTS FOR AIRCRAFT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Richard G. Ahlvin
Donald N. Brown

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

This paper presents limited background on ground-flotation criteria development and some of the concepts on which current criteria are based. It gives an insight into various problem areas in development of the criteria and explains the extent or limits of applicability of flotation criteria presently in use. In the final portion of the paper, emphasis is given to the particular aircraft characteristics that contribute good or high flotation and some discussion is presented of factors, not treated by current criteria, which recent research indicates may have a significant effect on flotation.

KEYWORDS: Aircraft; Ground flotation

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SOIL BUILDUP BETWEEN WHEELS AND SPONSON OF XM759 LOGISTICAL CARRIER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Edgar S. Rush

6. REPORT DATE October 1967	7a. TOTAL NO. OF PAGES 19	7b. NO. OF REFS 2
8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-940 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 902 843L	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

In tests of the XM759 logistical carrier on a sticky, heavy clay, serious soil buildup occurred between the tires and sponson. This experience led to a limited study in which a single wheel (24x21-6N Terra tire) from the XM759 was rolled through a heavy clay at various moisture contents and then over five metal and plastic panels to determine the effects of these possible sponson-construction materials on soil buildup. The materials tested were aluminum, steel, Teflon, Formica, silicone-sprayed aluminum, and nylon. Soil buildup was greatest on steel and least on Formica under optimum moisture conditions for soil accumulation. However, it is questionable whether one material is better than another once the sponson surface area has been completely covered with soil. The probability of occurrence of soil buildup conditions in South Vietnam was also investigated to a limited extent. Based on a number of assumptions, it was concluded that the probability of occurrence of conditions conducive to soil buildup is 3 percent of total land area of South Vietnam.

KEYWORDS: Cargo vehicles; Clays; Pneumatic tires; Soil buildup (Vehicles); Soil-wheel interaction; Terra-tires; [XM759 Logistical carrier] ; Amphibious vehicles

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EFFECTS OF TREAD PATTERN ON THE SURFACE TRACTION OF TERRA-TIRES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Smith, Jerry L.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
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8a. CONTRACT OR GRANT NO b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. Task -03 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-942 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 747 099

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT This study consisted of two test series conducted using seven Terra-tires, of which one had a smooth surface and the other six had various tread areas and patterns. The first series was to determine what effect adding tread to the Terra-tires on the MTV would have on its slope-climbing and pull-producing ability. Tests were conducted on a strong fat clay with a wet surface, and each test consisted of five passes with a single wheel powered at 20 percent slip, or locked in a full skid.

The second series evaluated four materials for possible use in sponson construction. These tests were conducted with the same seven Terra-tires on both wet and dry surfaces of each material. The wheel was either free rolling or locked.

In the in-soil tests, analysis of all five passes showed that the treaded tires, regardless of pattern, developed more traction and skid resistance than did the smooth tire. Tread pattern appeared to have little influence on the P/W values developed, but tread area influenced these values significantly. Tires with either too little or too much tread area performed poorly. The Terra-Grip and the non-directional bar tread appeared to have the best combination of tread area and tread arrangement of the tires tested. Performance in the locked-wheel tests followed the same general pattern as in the tests with the powered wheel.

In the tests to evaluate sponson materials, the performance of the free-rolling wheel showed no significant differences, regardless of the material used or the surface condition. In the locked-wheel tests, a given material generally offered greater resistance to a given tire when the material was dry, but there were some exceptions, notably on carborundum-impregnated aluminum. The highest skid resistance was developed on dry silicon carbide, the lowest on wet structural aluminum.

KEYWORDS: Clays; Laboratory tests; Pneumatic tires; Terra-tires; Tire tread patterns; Traction; [MTV]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer WAterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
A QUALITATIVE APPROACH TO THE PNEUMATIC TIRE-SOFT SOIL SYSTEM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Leland M. Kraft

6. REPORT DATE November 1967	7a. TOTAL NO. OF PAGES 33	7b. NO. OF REFS 10

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. 1-V-0-14501-B-52A-01, Research in Earth Sciences	Miscellaneous Paper No. 4-944
c. Task-01, Terrain Analysis	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This study was directed toward obtaining a fundamental understanding of the tire-soil system from a qualitative investigation of the behavior of pneumatic tires operating in soft soils, using failure theories of classical soil mechanics. A series of powered-wheel, programmed-slip performance tests conducted in sand and clay were analyzed.

The soil in contact with the tire is considered to be in a state of failure at all slips, and it is hypothesized that the characteristic shape of the pull-slip curve is not due to the increase in soil deformation, but to the rotation of the failure plane with respect to the tire-soil interface. Using some simple assumptions and the approximation that measured forces were uniformly distributed over the tire-soil contact surface, it is demonstrated that the hypothesis is a plausible one. A key element in the analysis is the determination of an angle θ that represents the angle of the tire contact surface relative to the horizontal. Using this angle and the forces measured in a test, a relation between the ratio of tangential and normal stresses and slip was developed. This relation is interpreted as a measure of the rotation of the failure plane. There appears to be a linear relation between θ and slip in sand, and a hyperbolic relation in clay.

A discussion of slip is included as Appendix A.

KEYWORDS: Laboratory tests; Pneumatic tires; Soft soils; Soil-wheel interaction; Trafficability

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
GROUND-FLOTATION INVESTIGATION OF MODEL WIDE TIRE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Technical Report

5. AUTHOR(S) (First name, middle initial, last name)
Watkins, James E.
Hill, Webster

6. REPORT DATE
September 1967

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Miscellaneous Paper No. 4-948

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
Distribution limited to U. S. Government agencies only; test and evaluation; December 1971. Other requests for this document must be referred to Air Force Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Air Force Flight Dynamics Laboratory
Research and Technology Division
AF Systems Command, WPAFB, Ohio

13. ABSTRACT

This report describes work undertaken as part of an overall program to develop ground-flotation criteria for the C-5A aircraft. A test section was constructed to a width adequate for seven similar test lanes. Each lane was divided into two unsurfaced items having different subgrade CBR values. Traffic was applied by a model wide tire, a multiwheel assembly, and a conventional single-wheel assembly. The same load and tire pressure were maintained for all tests. This report presents a description of the test section and wheel assemblies, and gives soil strengths, drawbar pull, and surface deformations and deflections. Also, the number of traffic passes completed before failure occurred on each test item is given. An analysis of traffic data, with conclusions, is presented.

KEYWORDS: Aircraft; Aircraft tires; Ground flotation; Pneumatic tires

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EXPEDIENT SURFACE-SOIL SAMPLING

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Sterling J. Knight
Claude A. Blackmon

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. DA 4A62040101 D859 Supplemental Dust Control c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-949 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 746 350

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers Department of the Army Washington, D. C. 20315

13. ABSTRACT

A study was made to determine practical, expedient methods of securing and containing surface-soil samples when soil sampling equipment is not available. Detailed examination of 24 cans, digging tests with three cans, and soil moisture-retention tests of eight types of covers indicated that any all-metal can makes a good tool for digging and containing surface-soil samples. A 12-oz beer can is judged to be a good choice for expedient surface-soil sampling because of its ubiquity, size, shape, sturdiness, and resistance to corrosion. A plastic cover that fits a round can snugly and two types of cloth-backed adhesive tape are considered to be effective covers for retaining the moisture in a soil sample in a can. Detailed procedures for surface-soil sampling are given.

KEYWORDS: Soil sampling

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

A LIMITED STUDY OF EFFECTS OF SOIL STRENGTH ON WALKING SPEED

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Edgar S. Rush
Adam A. Rula

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1967	23	0

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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers Department of the Army Washington, D. C. 20315

13. ABSTRACT

The purpose of this study was to establish a relation between soil strength and walking speed. Ten tests were conducted on fine-grained soil and a wide range of soil strengths with five walking participants in most tests. Best relations were developed between walking speed and depth of footprint versus soil strength in terms of cone index. Walking speeds ranged from 0 mph on a cone index of 6 to about 4 mph on a cone index of 11; average walking speed on pavement was 4.67 mph. Walking speed increased from 0 to about 4 mph for depths of 22 in. (immobilization) and 5 in., respectively. Between the 5- and 0-in. footprint depths, speed varied between 4.0 and 4.5 mph.

KEYWORDS: Fine-grained soils; Soil strength; Walking speed

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

APPLICATION OF TRAFFICABILITY ANALYSIS TO FORESTRY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Freitag, Dean R.
Richardson, Boone Y.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. 4-959 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 746 404

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at 1967 Meeting of the American Society of Agricultural Engineers, Detroit, Mich., 12-15 Dec 67 (No. 67-639)	U. A. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Analysis techniques developed at the U. S. Army Engineer Waterways Experiment Station for military trafficability studies are described. Similarities between operations of military vehicles and forestry vehicles are noted, and the results of tests conducted with a rubber-tired skidder are presented and analyzed.

KEYWORDS: Forestry vehicles; Military vehicles; Trafficability; Field tests; Mobility

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Waterways Experiment Station Vicksburg, Miss. 39180	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

PENETRATION TESTS FOR SOIL MEASUREMENTS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report.

5. AUTHOR(S) (First name, middle initial, last name)

Freitag, D. R.

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Presented at the 1967 Meeting of the American Society of Agricultural Engineers Detroit, Mich., 12-15 Dec 67 (Paper 67-652)	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

Penetrometers are well suited for measuring soil properties, but there are some factors that limit their applicability. Test data accumulated by the U. S. Army Engineer Waterways Experiment Station are used to identify these factors and to indicate their influence.

KEYWORDS: Penetrometers; Soil penetration tests; Soil property measurements

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

SUMMARY OF COMPARISON OF ENGINEERING PROPERTIES OF SELECTED TEMPERATE AND TROPICAL SURFACE SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Summary report

5. AUTHOR(S) (First name, middle initial, last name)

M. P. Meyer

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at Second International Conference on Mechanics of Soil-Vehicle Systems 8-66; & Geological Society of America 11-67	Advanced Research Projects Agency and U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

This paper summarizes a report, "Comparison of Engineering Properties of Selected Temperate and Tropical Surface Soils," published in June 1966. Field and laboratory tests were conducted on 11 fine-grained soils from the temperate climate of the United States and 17 fine-grained soils from the tropical climates of Puerto Rico, Panama Canal Zone, Hawaii, and Thailand to determine trafficability of the soils and other engineering properties. Soils were collected from the 6- to 12-in. layer for a wide range of parent materials. Temperate and tropical soils of each parent material were selected on the basis of their similarity in the Unified Soil Classification System and topographic position. A comparison of physical, mineralogical, and chemical properties, and results of standard and special engineering tests indicate, with few exceptions, no significant differences between temperate and tropical soils from a similar parent material. It is concluded that temperate and tropical soils of similar parent materials and Atterberg limits generally have other engineering properties that are similar and behave similarly when subjected to standard and special engineering laboratory tests. Differences in behavior between soils from each of the climates can be associated with differences in Atterberg limits.

KEYWORDS: Laboratory tests; Parent materials (Soils); Soil property relations; Soil property variations; Temperate regions; Trafficability; Tropical regions, [Hawaii, Panama C Z, Puerto Rico, Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

REPORT OF SECOND MEETING; VICKSBURG MOBILITY EXERCISE A; DESIGN OF FIELD TEST PROGRAM (8-10 February 1967, Vicksburg, Mississippi)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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5. AUTHOR(S) (First name, middle initial, last name)

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
See Miscellaneous Paper No. 4-702.	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A second meeting of a group of mobility, soil, and terrain evaluation specialists of the U. S. Army Materiel Command and the U. S. Army Corps of Engineers, together with associated consultants, was held at the Waterways Experiment Station 8-10 February 1967 to design and implement an agreed-upon field program for testing the three vehicle test beds.

KEYWORDS: Meetings; Mobility; Vehicle design; [Vicksburg Mobility Exercise A]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
GAMMA-RAY MEASUREMENTS TO EVALUATE SOIL PROPERTIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Albert N. Williamson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES Paper presented at Fifth Symposium on Remote Sensing of Environment, University of Michigan, 16-18 April 1968; Published in Proceedings.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Gamma radiation from soil samples obtained from nearly all of the states and Puerto Rico was measured in the laboratory and the results were analyzed to evaluate the use of gamma-ray measurements to convey certain information about the soil. The data were arranged according to land usage, i.e. cultivated or uncultivated, and into classifications according to the following systems: geological material type, geological material age, U. S. Department of Agriculture (USDA) Great Soil Group, and USDA Soil Order based on the Seventh Approximation. By plotting the gamma-ray photopeak count ratios of Th^{232}/K^{40} versus U^{238}/K^{40} and the normalized photopeak counts for U^{238} and Th^{232} versus sand content, it was shown that the criteria for separating the soils were either too broad or not significant to the gamma-ray emissive characteristics of soil. However, the data showed that the Th^{232} and U^{238} photopeak counts depended upon the particle size distribution in the soil and indicated that gamma-ray measurements can provide a qualitative indication of sand content.

KEYWORDS: Gamma rays; Laboratory tests; Remote sensing; Soils

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EFFECTS OF TEST TECHNIQUES ON WHEEL PERFORMANCE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Newell R. Murphy, Jr.
Andrew J. Green

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046, "Trafficability and Mobility Research c. Task 03, Mobility Fundamentals and Model Studies d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. M-68-1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 746 758

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11. SUPPLEMENTARY NOTES Presented at 2d Int Conf on the Mech of Soil-Vehicle Systems of ISTVS, Quebec, Canada, 1966, Abstract titled "Evaluation of Single-Wheel Testing Techniques." Pub. Jour Terr, Vol 6, No. 1, 1969.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

A study was made of the effects of various testing techniques on the performance of a test wheel mounted with a pneumatic tire operating in an air-dry desert sand. Tests employing both controlled-slip and controlled-pull techniques were conducted with a single-wheel, dynamometer-equipped carriage. The results are presented in the form of graphs with emphasis placed upon the pull-slip and torque-slip relations. For the conditions tested, wheel performance was found to be independent of testing techniques with one exception: Consistent differences were noted when comparing results of programmed-increasing and programmed-decreasing slip tests. Although this disagreement occurred only for a narrow range of slip (approximately -10 to +10 percent), it can be important.

A brief analysis of the horizontal forces acting on the dynamometer is given to amplify certain relations, particularly differences in pull-slip and drawbar pull-slip responses. It is shown that because of the inability to always attain a stable condition, controlled-slip tests are better than controlled-pull tests for defining pull-slip and torque-slip relations.

KEYWORDS: Laboratory tests; Pneumatic tires; Sands; Soil-wheel interaction; Test techniques; Tire performance

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

DESCRIPTION AND COMPARISON OF TIRE PERFORMANCE IN SAND IN TERMS OF ENERGY PARAMETERS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

E. Leflaive

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented at 2d International Conference on the Mechanics of Soil-Vehicle Systems of ISTVS, Quebec, Canada, 29 Aug-2 Sep 66 Abstract in Proceedings	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Some typical aspects of the rolling motion of pneumatic-tired wheels in dry sand are described in qualitative terms. The positive slip range, between the self-propelled condition and 100 percent slip, is considered. In this range, three phases of the phenomenon are distinguished according to the rate of variation of torque and pull. The parameters used for the description are energy coefficients: torque, pull, and dissipated energy coefficients. Experimental results are given to illustrate this approach.

The first part of the paper describes the three phases of rolling motion with respect to slip and defines the energy parameters. The second part is a discussion of the observed effects of wheel load, sand strength, and tire characteristics upon (a) the rate of increase of torque at low slips, (b) the value of the maximum pull/load ratio, and (c) the rates of increase of torque energy and dissipated energy at medium and high slips.

This discussion illustrates the physical understanding of rolling motion in sand that can be gained from the comparative study of each phase for various tires under various load and soil conditions. Such a comparison provides a means of specifying the differences in performance between different tires. The discussion also questions the agreement between observed facts and existing theories. It is found that important aspects consistently observed in tire performance are not predicted by any present theory.

KEYWORDS: Laboratory tests; Pneumatic tires; Sands; Soil-wheel interaction; Tire performance

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

TRAFFICABILITY TESTS WITH MAJOR/MINOR WHEEL VEHICLE EQUIPPED WITH 16x14.5-6 TIRES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

James H. Robinson
Edgar S. Rush

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Limited War Laboratory Aberdeen Proving Ground, Maryland

13. ABSTRACT

The major/minor wheel vehicle, an experimental vehicle that employs the Terrastar locomotion concept, was tested on soils having a wide range of strengths, on asphalt pavement, and in water. The purpose of the tests was to determine (a) the minimum soil strength, in terms of rating cone index, that will permit the vehicle to complete one and 50 passes in a straight-line path (i.e. the vehicle cone index for one pass, VCI_1, and 50 passes, VCI_{50}), (b) one-pass drawbar pull-slip and motion resistance-soil strength relations, (c) hard surface drawbar pull-vehicle speed relations, (d) slope-climbing capabilities, (e) water speed, and (f) water exit capabilities. Mechanical breakdowns prevented completion of some portions of the test program. The experimental VCI_{50} was determined to be 21 and the experimental VCI_1 to be 8. This compares favorably with the computed VCI_{50} of 27 and computed VCI_1 of 14. The maximum drawbar pull on a paved surface was 65 percent of vehicle weight; the maximum drawbar pull on soil was about 57 percent of vehicle weight. Maximum drawbar pull and motion resistance were shown to be related to soil strength. The maximum water speed was 3.0 mph. Appendix A presents the fromula and computations for determination of the vehicle cone index.

KEYWORDS: Field tests; Mobility; Pavements; Terrastar locomotion concept; Trafficability; Water performance

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
SIMULATING DYNAMIC RIDE CHARACTERISTICS OF PNEUMATIC TIRES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
Allan S. Lessem

6. REPORT DATE
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11. SUPPLEMENTARY NOTES
Presented at Forest Eng. Conf. ASAE, Sept 1968, Proceedings Paper No. FE 3168.

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT
The data shown indicate that a mathematical representation of pneumatic tire, in terms of the deflections of many radial segments, successfully displays the essential feature of horizontal and vertical forces transmitted through the tire. It is indicated further that the segmented tire model enables realistic predictions to be made of the displacement and force time histories for a pneumatic tire towed over a rigid obstacle.

KEYWORDS: Mathematical models; Obstacle-wheel interaction; Obstacles; Ride dynamics; Simulation; Tire deflection; Pneumatic tires

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STRESS-DISPLACEMENT RELATIONS AND TERRAIN-VEHICLE MECHANICS: A CRITICAL DISCUSSION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

Klaus W. Wiendieck

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Journal Terramechanics, Vol 5, No. 3, 1968.	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT Current theoretical concepts of the soil-running gear interaction are based on empirical pressure-sinkage and shear stress-displacement relations. It was found that the tests from which these relations were obtained present a poor analogy, at best, to the soil-running gear interaction. In particular, the use of the shear stress-displacement relation for an analytical evaluation of the shear stresses at the contact surface of rigid wheels on sand was found to be misleading, primarily because equations obtained by the bevameter or dragged plate tests describe the soil behavior in the intermediate state, which is a state between the elastic and plastic states. Recent publications point out that part of the soil in the immediate vicinity of a powered wheel is in a state of actual plastic flow and part is in a quasielastic state. Thus, the soil-bevameter interaction is of a fundamentally different nature than the soil-wheel interaction, which makes results of such tests unsuitable for predicting wheel performance. Sela's theory of the relation between a rigid wheel and dry sand is based exclusively on the shear stress-displacement concept, and thus provided an excellent means of checking the concept as a whole. Using a simple approximate relation between the M/RW ratio and the mean shear-to-normal stress ratio taken over the total contact surface, the theory was checked by means of constant-slip rigid wheel tests. The experimental findings strongly supported the conclusion that shear stress-displacement relations are irrelevant to soil-wheel mechanics. A new theory was developed to assess the variation of the shear-to-normal stress ratio along the soil-wheel interface, without referring to shear stress-displacement relations. This is a subject of another paper.

KEYWORDS: Soil-wheel interaction; Stress-strain relations (Soils); Stresses under wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A MATHEMATICAL MODEL FOR TRAVERSAL OF RIGID OBSTACLES BY A PNEUMATIC TIRE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Allan S. Lessem

Andrew J. Green

6. REPORT DATE December 1968	7a. TOTAL NO. OF PAGES 17	7b. NO. OF REFS 3

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11. SUPPLEMENTARY NOTES Published in Army Science Conf. Proceed.; 18-21 Jun 1968, Vol 2.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The mathematical model for a pneumatic tire described in this paper is used to compute the horizontal and vertical forces transmitted through the tire to the vehicle axle to provide realistic force inputs for model studies of vehicle dynamics. The present model is valid for the case of a pneumatic tire traversing nondeforming obstacles with zero slip. Static load-deformation characteristics and dynamic obstacle-traversal characteristics were obtained in laboratory test with 9.00-14 tires under several conditions of ply rating and inflation pressure. These data were used to calculate model parameters and to produce time histories of dynamic responses. Computer implementation of the mathematical model produced force and displacement time histories similar to those obtained during the obstacle-traversal laboratory tests. The model produced the essential features of the waveforms seen in the laboratory and is a valid representation of a pneumatic tire for dynamic analysis of vehicles on nonyielding terrain.

KEYWORDS: Mathematical models, Mobility; Obstacle-wheel interaction; Pneumatic tires; Ride dynamics

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A THEORETICAL EVALUATION OF THE SHEAR-TO-NORMAL STRESS RATIO AT THE SOIL-WHEEL INTERFACE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus W. Wiendieck

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

An attempt is made to theoretically assess the variation of the shear-to-normal stress ratio, t/σ, along the soil-wheel interface without referring to shear stress-displacement relations believed to be irrelevant. Based on recent investigations of the soil rupture pattern beneath rigid wheels on cohesionless material, the total soil-wheel interface is subdivided into three zones of different soil behavior. Simple assumptions are made of the soil-to-wheel movements within these zones to evaluate t/σ. Experimental checks showed the approach developed herein to be in better agreement with the test data than were previously developed theories.

KEYWORDS: Soil-wheel interaction; Stress-strain relations (Soils); Stresses under wheels

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3. REPORT TITLE
TRAFFICABILITY TESTS WITH A RUBBER-TIRED LOG SKIDDER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)
James H. Robinson
Robert P. Smith
Boone Y. Richardson

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	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT
Trafficability tests were conducted with a log skidder to determine the applicability of the U. S. Army Engineer Waterways Experiment Station (WES) mobility index formula to articulated, rubber-tired, four-wheel-drive vehicles. Self-propelled tests without and with a 4000-lb rear axle load were conducted to determine experimentally the minimum soil strength, or vehicle cone index (VCI), for one-pass (VCI_1) and 50-pass (VCI_{50}) straight-line operations. Drawbar pull-slip and motion resistance-soil strength relations for soils ranging in strength from 25 to 104 rating cone index (RCI) were determined. The experimental VCI_{50} was determined from self-propelled tests performed on heavy clay and lean clay soils to be 33 without a rear axle load and 38 with a load, which is approximately 3 RCI units on the conservative side. The experimental VCI_1 was determined to be 16 with load and 14 without load. Seven drawbar pull tests with load and five tests without load were performed on soils classified as organic silt (in the 0- to 2-in. layer) and fat clay (in the 2- to 39-in. layer). Good correlation was obtained between both drawbar pull at 40% slip and maximum drawbar pull at ≤95% slip and cone index (CI) of the surface layer, at the 3-in. depth, and of the 0- to 6-in. layer, respectively. Correlations between drawbar pull and RCI were not as good as those between drawbar pull and CI. Drawbar pull correlated well with the surface shear stress as measured with the Cohron sheargraph. The WES formula and computations for the determination of VCI for the log skidder are presented in Appendix A.

KEYWORDS: Clays; Field tests; Logging vehicles; Mobility; Organic soils; Trafficability; [Log skidder]

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U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi 39180

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
VEHICLE DYNAMICS RESEARCH AT WATERWAYS EXPERIMENT STATION

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report

5. AUTHOR(S) (First name, middle initial, last name)
Andrew J. Green, Jr.
Gerald W. Switzer

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Presented at the CAL-ISTVS Off-Road Mobility Research Symposium in Washington, D. C., 26-27 Jun 68.

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT
Existing research facilities at U. S. Army Engineer Waterways Experiment Station (WES) are being utilized in a systematic approach to developing and validating more reliable models of the man-vehicle-terrain system. Specific attention is being given to developing more realistic models of tires, tracks, and deforming soil. The dynamometer systems at WES are being utilized to evaluate these models and to determine dynamic characteristics of certain tires and track systems. High-speed computing facilities are being used extensively, and capabilities for in-house simulation activities are being increased. Obstacle courses and test tracks will be used to evaluate analytical models and assess the validity of criteria for determining ride quality and/or vehicle speed.

KEYWORDS: Mathematical models; Mobility; Mobility research laboratories; State-of-the-art studies; Vehicle dynamics; [Waterways Experiment Station]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE
LIMITED TRAFFICABILITY TESTS WITH MAJOR/MINOR WHEEL VEHICLE EQUIPPED WITH 20x14-10 TIRES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Robert P. Smith
James H. Robinson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Limited War Laboratory, Aberdeen Proving Ground, Maryland

13. ABSTRACT

The major/minor wheel vehicle is an experimental vehicle that employs the Terrastar locomotion concept. A previous test program was conducted with the vehicle equipped with 16x14.5-6 tires, whereas in this program the vehicle was equipped with 20x14-10 tires. The main purpose of the program was to determine whether the larger tires improved vehicle performance. Performance parameters were go or no-go, one and 50 passes, in soft soil; maximum water speed; water exit; and vertical step height capabilities. Mechanical breakdowns reduced considerably the amount of testing compared to that anticipated at the start of the program. Comparison of the results of the two programs shows that the larger tires reduced one-pass soft soil vehicle cone index from 8 to 5 and increased maximum water speed from 2.8 to 3.1 mph. Water exit capabilities were at least as good with the larger tires. A vertical step height of 22 in. was mounted with ease with the 20x14-10 tires. Step height tests were not attempted with the vehicle equipped with the smaller tires.

KEYWORDS: Field tests; Mobility; Soft soils; Soil-wheel interaction; Terrastar locomotion concept; Trafficability; Water performance; Wheeled vehicles

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1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	Unclassified
	2b. GROUP

3. REPORT TITLE

UTILITY CARRIER DEVELOPMENT PROGRAM: Report 1, LIMITED STUDY OF EFFECTS OF JUNGLE TRAIL CHARACTERISTICS ON PERFORMANCE OF SELECTED SELF-PROPELLED VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 1 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Edgar S. Rush

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A series of reports prepared by the Joint Thai-U. S. Military Research and Development Center were reviewed to determine the effects of jungle trail features, especially trail width, on performance of the M274 ½-ton Carrier and two concept vehicles, one 65 in. and the other 80 in. wide. In these reports it was generally concluded that vehicles whose widths approached 90 in. experienced difficulty along the trails. Overhanging vegetation and fallen trees restricted driver visibility and damaged windshields of vehicles whose heights were about 80 in. or more. Slippery soils and steep streambanks plagued trail operations; deep ruts in the trail surface also caused considerable problems. Nonamphibious vehicles experienced numerous engine failures in fording operations. Streams deep enough to float vehicles had current velocities less than 3 mph. Based on the review of these reports, the following suggestions are made. The vehicle should be less than 90 in. wide and less than 80 in. high. Ground clearance should be greater than 18 in. and the underbody should be smooth. The turning radius should be less than 15 ft. The traction elements should have the traction capabilities of a track and the low maintenance requirements of a wheel. The vehicle should be amphibious and should be able to maintain directional control against a current velocity of 3 mph. However, if nonamphibious but equipped with waterproof ignition and exhaust systems, the vehicle would meet approximately 90 percent of the requirements for water crossing. The vehicle should have a high-capacity winch and power steering or easy steering capabilities. Ground pressures in the order of 2 psi or less are desirable for soft soils that may be encountered.

KEYWORDS: Field tests; Jungle trails; Military vehicles; Mobility; Self propelled vehicles; Terrain analysis; Trafficability; Tropical regions; Utility carriers
[Thailand]

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1. ORIGINATING ACTIVITY (Corporate author)

U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION

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3. REPORT TITLE

UTILITY CARRIER DEVELOPMENT PROGRAM; Report 2, LIMITED STUDY OF EFFECTS OF VEGETATION CHARACTERISTICS ON PERFORMANCE OF SELECTED SELF-PROPELLED VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Report 2 of a series

5. AUTHOR(S) (First name, middle initial, last name)

Thomas D. Hutto
Joseph L. Decell
Adam A. Rula

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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

A desk study was performed to determine the effects of vehicle and vegetation characteristics (particularly vehicle width) on vehicle performance. The 1/2- and 3/4- ton, 8x8 vehicle concepts and the 1/2-ton, 4x4 M274A2 Mule were included in the study, and performance predictions were made for 150 wooded vegetation sites located in a variety of environments. Vehicle performance was evaluated by analyzing the predicted performance data obtained from the application of the WES analytical model for predicting country performance. For this study, performance predictions were made in terms of speed and delivery rate as a function of vegetation stem size and spacing and vehicle characteristics only. The results of the study revealed that the M274A2, with the narrowest width, lowest power, and smallest payload, had the least number of immobilizations and the lowest average speed and delivery rate; the 1/2-ton vehicle concept with an intermediate width, power, and payload, ranked second in the number of immobilizations, had the highest average speed, and ranked second in delivery rate; and the 3/4-ton vehicle concept, with the greatest width, power, and payload, had the highest number of immobilizations and the highest average delivery rate. It was also concluded that the poorer performance of the 3/4-ton vehicle concept as compared to the 1/2-ton vehicle concept may be offset by incorporating the General Electric Co. hydromechanical power train described herein.

KEYWORDS: Military vehicles; Mobility; Performance predictions; Performance tests (Vehicles); Utility carriers; Vegetation factors

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE ROLE OF GROUND CRAWLING VEHICLES IN THE OCEAN

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus W. Wiendieck
Dean R. Freitag

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
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8a. CONTRACT OR GRANT NO b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-69-6 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Published in Proceed. of ASCE Conf. on Civil Engineering in the Ocean, Dec 1969.	U. S. Naval Civil Engineering Laboratory Port Hueneme, California

13. ABSTRACT

As undersea technology is quickening its pace, the need for ocean-bottom vehicles is becoming increasingly obvious for many anticipated underwater activities, such as inspection of cables and pipelines, scientific exploration, and commercial exploitation (mining and farming) of and construction on the seafloor. Submersibles designed for a three-dimensional environment are inadequate for operation on or near the essentially two-dimensional seafloor. In contrast to submersibles, ocean-bottom crawling vehicles are stable even while at rest, because they are in direct contact with the seafloor, which also provides the necessary reaction forces to perform useful work. Some ocean-bottom vehicles are already available, and more are under construction; but a comprehensive study of seafloor trafficability and vehicle mobility has not been made. This paper presents the state of trafficability and mobility knowledge as applied to onshore vehicles, and discusses its applicability to the seafloor environments. The mechanical and geometrical properties of the ocean bottom are briefly analyzed in the light of trafficability concepts. Various running gears are compared as to their suitability for the ocean bottom, and their advantages and disadvantages with respect to slope-climbing ability, drawbar pull, effect on turbidity, etc., are presented. Since off-road mobility research is basically empirical, definite conclusions cannot be drawn without adequate support by laboratory and in situ testing. This paper is an outgrowth of a U. S. Army Engineer Waterways Experiment Station contract report for the U. S. Naval Civil Engineering Laboratory, in which more details and a minimum test program to establish a rational basis for mobility prediction of ocean crawling vehicles can be found.

KEYWORDS: Mobility; Ocean bottom vehicles; Trafficability

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3. REPORT TITLE

EFFECTS OF CONE VELOCITY AND SIZE ON SOIL PENETRATION RESISTANCE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage
Dean R. Freitag

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Presented ASAE Meeting, Dec 1969, Paper No. 69-670.	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Data show the cone penetration resistance of fine-grained soils is proportional to velocity and inversely proportional to cone diameter. An exponential equation based on the velocity-diameter ratio is developed to describe the interrelation. The exponent changes only slightly with soil type.

KEYWORDS: Cone penetrometers; Fine-grained soils; Penetration resistance (Soils)
Soil penetration tests

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP
3. REPORT TITLE A GENERAL THEORY OF STRESSES AND DISPLACEMENTS IN ELASTIC AND VISCOELASTIC LAYERED SYSTEMS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (First name, middle initial, last name) Yu-Tang Chou	
6. REPORT DATE December 1969	7a. TOTAL NO. OF PAGES 30; 7b. NO. OF REFS 8
8a. CONTRACT OR GRANT NO.; b. PROJECT NO. 1T061102B52A; c. Task 01; d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-69-8; 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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11. SUPPLEMENTARY NOTES Published in Transactions of the 15th Conference of Army Mathematicians, June 1969; Report ARO-D, No. 70-1, USARO.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command, Washington, D. C.

13. ABSTRACT

The analysis of linear viscoelastic layered systems under any axially symmetrical, time-dependent surface traction is presented. Inertial effects are disregarded, and solutions are obtained for the normal, radial, and shear stresses, vertical deflection, and radial displacements at any point within the half space in multilayered systems. Solutions in layered elastic systems first are obtained by using the Love's stress function and the Fourier-Henkel transformation. Solutions in viscoelastic cases then are obtained by using the elastic-viscoelastic correspondence principle, in which the Laplace transformation is applied to replace the time variable with a transformed variable, and thus change the viscoelastic problem into an associated elastic one. The solution of the associated elastic problem, when transformed into the real time variable, will give the desired viscoelastic solution. Sample numerical results are presented. The analysis is an essential step in the development of a rational method of design for flexible pavements, since such pavement systems respond in a markedly time-dependent fashion.

KEYWORDS: Displacement; Flexible pavements; Layered systems; Stress-strain relations; Viscoplasticity method

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EVALUATION OF NUCLEAR METHODS OF DETERMINING SURFACE IN SITU SOIL WATER CONTENT AND DENSITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Thomas B. Rosser III
Steve L. Webster

6. REPORT DATE April 1969	7a. TOTAL NO OF PAGES 36	7b. NO OF REFS 7
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers, U. S. Army Washington, D. C.

13. ABSTRACT

Laboratory tests were conducted to evaluate the accuracy and reliability of measuring surface in situ soil water content and density by the backscatter and direct transmission nuclear methods using a single nuclear device and scaler. The nuclear device functioned as a surface backscatter moisture and density meter or as a direct transmission density probe. To determine the accuracy of the nuclear measurements, it was necessary to know the actual density and water content of the test soil Boxes were fabricated to exact dimensions, filled with uniformly compacted soil, and weighed, and actual average soil density values were calculated. Five soil types were tested to approximate a full range of possible construction materials. Each soil type was tested at eight different densities and water contents. To obtain comparative results, soil densities of each sample were determined by two accepted conventional methods (sand-cone and water-balloon) for determining density in the field. Test results indicated that in situ densities determined by the direct transmission nuclear method using the factory calibration curve furnished with the device were as accurate as densities obtained by the sand-cone and water-balloon methods. The direct transmission nuclear method using a WES-developed calibration curve provided slightly more accurate density measurements than either conventional method. Densities determined by the surface backscatter nuclear method using both the factory calibration curve and a WES-developed curve were not so accurate as those obtained by the conventional methods. Water contents were obtained by nuclear means and compared with actual water contents determined from ovendried samples. Using a WES-developed calibration curve, water contents obtained by the nuclear method were sufficiently accurate for most quality control fieldwork. Water contents obtained using the factory calibration curve were not accurate enough for field use. A test procedure for determining surface layer density and water content of soil by nuclear methods is presented in Appendix A

KEYWORDS: Measuring instruments; Nuclear methods; Soil density determination; Water content determination (Soils)

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE WORLDWIDE STRENGTH CONDITIONS OF SURFACE MATERIALS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (First name, middle initial, last name) Marvin P. Meyer William P. Bohnert, Jr.	
6. REPORT DATE April 1970	7a. TOTAL NO. OF PAGES 29 / 7b. NO. OF REFS 14
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Department of the Navy Naval Weapons Center China Lake, California

13. ABSTRACT

Gross surface material strength conditions were mapped on a worldwide basis and more detailed surface strength conditions were mapped for South Vietnam to provide a source of data for design and deployment criteria for missile and munitions systems. The top 15 cm of surface material, including soil, rock, or snow, was mapped in terms of five cone index (CI) classes: >150; 75-150; 45-75; 0-45, soil; and 0-45, snow. Each areal delineation on the map was assigned an average CI class for each of three four-month periods during the year in order to characterize the seasonal climatic effects on soil strength. The world soil strength map is portrayed on a Goode's homolosine projection with an equatorial scale of 1:26,500,000, and the strength map of South Vietnam is portrayed on a Lambert conformal conic projection of approximately 1:1,750,000. Information used for the development of the mapping system was derived from 14 sources of soil strength, state-of-ground, climatic, and soil morphological data. A planimetric analysis of world strength conditions is presented as Appendix A.

KEYWORDS: Snow strength; Soil strength; Soil strength maps; World maps; [South Vietnam]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PERFORMANCE EVALUATION OF WHEELS FOR LUNAR VEHICLES (SUMMARY REPORT)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Summary report

5. AUTHOR(S) (First name, middle initial, last name)
Dean R. Freitag
Andrew J. Green
Klaus-Jurgen Melzer

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11. SUPPLEMENTARY NOTES Details of this report included in WES TR No. M-70-2.	12. SPONSORING MILITARY ACTIVITY George C. Marshall Space Flight Center National Aeronautics and Space Administration, Huntsville, Alabama

13. ABSTRACT

One pneumatic wheel, four metal-elastic wheels, and two instrumented vehicles were laboratory tested in a fine sand to determine their relative performance and to establish a better understanding of the basic principles of the interaction of very lightly loaded wheels with a soil whose properties were varied to include the probable range of lunar soil properties. Programmed-slip tests were conducted with the single wheels and the vehicles, the latter being tested on both slopes and level surfaces. Data indicate that for loads less than about 220 N (50lb), the pull/slope-climbing ability was constant for a given soil condition. At greater loads, the rate of increase in performance decreased. The effect of cohesion on performance was negligible at loads less than about 220 N (50 lb), but the effect could be seen at higher loads. The results of tests with the metal-elastic wheels showed that none could be relied on to propel a vehicle up a 35-deg slope. Modifications of the Bendix and Grumman wheels enhanced their performance to the point that they might be expected to climb slopes in excess of 30 deg. Tests with modified Boeing-GM wheels indicated that they might be used on slopes up to about 25 deg on certain soil conditions. The power required, in whr/km, for operation of the wheels on level and sloping soil surfaces was determined. It was demonstrated that data from single-wheel tests can be used to predict the slope-climbing ability of a vehicle; such predictions tend to be slightly conservative. Results of tests with the vehicles indicate that the torque coefficient at a given slip was not significantly affected by variations in surface slope and soil strength.

KEYWORDS: Laboratory tests; Lunar roving vehicles; Sands; Soil-wheel interaction; Wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EFFECT OF PRESSURE DISTRIBUTION UNDER PNEUMATIC TIRES ON STRESSES AND DISPLACEMENTS IN THE SUPPORTING ELASTIC MEDIA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Yu-Tang Chou

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Summary published in Highway Research Record, No.345, 1971.	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The validity of the assumption of uniform pressure distribution under a pneumatic tire was checked in this study. Measurements of pressure distributions under pneumatic tires at their interface with firm surfaces and soft soils, previously made at the U. S. Army Engineer Waterways Experiment Station, were used. Two tires (11.00-20, 12-PR, and 12-22.5, 12-PR) tested at three inflation pressures (104, 207, and 414 kN/m^2) and under wheel loads ranging from 6670 to 20,030 N were investigated. Stresses and displacements were computed by the theory of elasticity for various depths in the half-space under loading conditions: measured, assumed uniform, assumed parabolic, and assumed conical pressure distributions. Generally, the assumption of uniform pressure distribution was found to be unreasonable in cases of high-inflated tires on a hard surface and on sands, but it was found acceptable in the other investigated cases, including those for clay surfaces. However, the assumption of parabolic pressure distribution was found to be more realistic than that of a uniform one for high-inflated tires on sands and for low-inflated tires with light load on loose sand.

KEYWORDS: Elastic media; Laboratory tests; Pneumatic tires; Pressure distribution; Stresses under wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A PLAN FOR QUANTITATIVE EVALUATION OF THE CROSS-COUNTRY PERFORMANCE OF PROTOTYPE VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Warren E. Grabau
Jack K. Stoll
Beryl G. Stinson

6. REPORT DATE September 1970	7a. TOTAL NO OF PAGES 109	7b. NO. OF REFS 7
8a. CONTRACT OR GRANT NO b. PROJECT NO 1V025001A131 and 1V02170'A046 c. ARPA Order No. 400 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-70-7 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 877 016	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A method of evaluating the cross-country performance of vehicles using quantitative descriptions of the terrain and a mathematical model that relates terrain parameters to vehicle performance is presented. A delivery index equation is introduced that gives a measure of cargo delivery over a specified terrain for a specified mission considering speed made good, loading and unloading time, servicing time, cruising range, and cargo capacity. The vehicle performance evaluation procedures are illustrated by applying them in a comparative analysis of the M37 and XM561 cargo trucks traversing selected terrains in the vicinity of Khon Kaen, Thailand. Quantitative terrain maps and mobility maps (in terms of speed made good) that were used to evaluate the relative performances of the M37 and XM561 are included. Appendixes present a tentative selection of "standard terrains" that could be used in evaluating relative performances of vehicles and a first-generation computer program for predicting speed performance. It is recommended that research be continued to improve the reliability and scope of the mathematical model for predicting vehicle performance and that areas of the world be selected and mapped as standard terrains for use as performance evaluation bases.

KEYWORDS: Computerized models; Military vehicles; Mobility models; Offroad mobility; Performance predictions; Terrain factor maps

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.		2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE TESTS WITH AN EXPERIMENTAL WHEEL ON CLAY		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report		
5. AUTHOR(S) (First name, middle initial, last name) Klaus W. Wiendieck		
6. REPORT DATE December 1970	7a. TOTAL NO. OF PAGES 17	7b. NO. OF REFS 0
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 4A013001A91D, In-House Laboratory Independent Research Program c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-70-8 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
10. DISTRIBUTION STATEMENT Approved for Public Release; Distribution Unlimited		
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Assistant Secretary of the Army (R&D) Department of the Army Washington, D. C. 20310	

13. ABSTRACT

An extension of a previous study on sand, this report summarizes the test results obtained on clay with an experimental wheel with controlled circumferential rigidity. The test program was carried out for the sake of completeness despite the fact that the underlying principle of the experimental wheel was based upon sand properties and, therefore, similar wheel performance variations as a function of tire rigidity distribution were not to be expected on clay. In addition, insufficient torque capacity of the wheel-drive system prevented the performance criteria used in the sand study from being applied in this study on clay.

The relation of pull/load to efficiency was the only feasible relation that could be used in this investigation. As expected, no noticeable change in tire behavior could be observed for rigidity pattern variations. Control of tire rigidity distribution at the interface is not effective in clay. Although this conclusion is negative, it confirms the earlier findings on the improvement of performance of the wheel with controlled circumferential rigidity in sand.

KEYWORDS: Clays; Laboratory tests; Rigid wheels; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

LIMITED PERFORMANCE TESTS OF THE XM759, 1-1/2-TON LOGISTICAL CARRIER, AMPHIBIOUS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Barton G. Schreiner
Edgar S. Rush

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT

Distribution limited to U. S. Government agencies only; test and evaluation of military vehicles; December 1970. Other requests for this document must be referred to the U. S. Army Engineer Waterways Experiment Station.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Limited performance tests were conducted with the XM759, 1-1/2-ton Logistical Carrier, Amphibious, at test sites near Vicksburg, Miss., and in Virginia in 1967, 1968, and 1970. The purpose of the tests was to provide personnel responsible for the overall development program with some urgently needed information on certain aspects of the vehicle's performance such as steering capabilities in water, effects of slippery surfaces on slope-climbing capabilities of smooth (treadless) tires and bar- and chevron-tread tires, effects of tread design on performance in marshland, effects of soil and vegetation buildup, and other performance capabilities of lesser significance. Most of the findings of these tests have been incorporated in the development program; this report serves to document the data upon which the development decisions were made. Generally, the findings were as follows. Bar-tread-design tires on the XM759 afforded the best slope-climbing and drawbar pull performances on wet clay surfaces. Performance of the XM759 was as good as or better than that of the M116 tracked cargo carrier. However, performance of the XM759 with bar-tread tires in marshlands was poor. Pilot vehicle (PV)5 modified with 25x24-8R chevron tires and having a gross weight of 17,480 lb performed as well in marsh areas as PV4 with 24x21-6R smooth tires and having a gross weight of 14,030 lb. Appendix A presents results of a laboratory study of the effects of tread-plate configuration and surface conditions on traction.

KEYWORDS: Amphibious vehicles; Field tests; Mobility; Performance tests (Vehicles); Slope performance; Soil buildup (Vehicles); Tire-tread patterns; Trafficability; Utility carriers; [XM759 (Vehicle)]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
EFFECTS OF SOIL SURFACE CONDITIONS ON DRAWBAR PULL OF A WHEELED VEHICLE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Summary of information reported in WES Technical Memorandum No. 3-240, Supplement 19

5. AUTHOR(S) (First name, middle initial, last name)
Edgar S. Rush

6. REPORT DATE December 1970	7a. TOTAL NO. OF PAGES 24	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper No. M-70-10 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Paper presented at Meeting of Off-Road Mobility Symposium 3-4 Nov 1970, Los Angeles, Calif., sponsored by ISTVS and TRW Systems Group; Published in Proceedings.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Tests were conducted with one wheeled vehicle to determine effects of soil surface conditions on drawbar pull and to relate optimum drawbar pull to soil strength as measured by a number of instruments. One hundred and six drawbar pull-slip tests ·re conducted with an M37 3/4-ton truck at a gross weight of 7240 lb One tire size 00-16, 8-PR), two tread patterns (smooth and nondirectional military), and two tire deflections (15 percent and 35 percent) were tested. Surface conditions varied from dry and firm to wetted with small amounts of water to flooded. Asphalt surfaces also were tested. Measurements of soil strength were made with the standard cone penetrometer, multiprobe penetrometer, sheargraph, soil truss, and friction wheel. Analysis of data indicated that the multiprobe penetrometer and sheargraph show the most promise as instruments for measuring surface conditions and predicting vehicle performance. Equations were developed for predicting drawbar pull based on deflection and soil measurements with the sheargraph and multiprobe penetrometer.

KEYWORDS: Drawbar pull; Field tests; Mathematical analysis; Soil strength test instruments; Soil-wheel interaction; Surface soil strength; Trafficability; Trucks; [M37 truck]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

EVALUATION OF SOIL STRENGTH OF UNSURFACED FORWARD-AREA AIRFIELDS BY USE OF GROUND VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

George M. Hammitt II

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Office, Chief of Engineers, U. S. Army Washington, D. C.

13. ABSTRACT

This report describes a method for rapidly determining the soil strength at forward-area airfields. Through the use of dimensionless ground mobility parameters developed by the U. S. Army Engineer Waterways Experiment Station, soil strength indications are determined by measuring rut depths created by traffic of standard military ground vehicles. This method enables reasonably accurate assessment of soil strength by personnel without special training and without the use of special instruments. If the soil strength existing in the forward areas is known, predictions can be made concerning the ability of a particular site to sustain specific aircraft traffic. Initially, an office study was conducted that established the potential of such a method. Then limited field verification tests were conducted with four standard military ground vehicles, i.e. a 1/4-ton M151, a 3/4-ton M37, a 2-1/2-ton M35A1, and a 5-ton M55, operated on a prepared unsurfaced heavy clay subgrade with a strength of approximately 2 CBR. First-pass rut depths were measured for each vehicle operated empty and for all but the M55 with maximum cross-country loading. The results of this testing indicated the feasibility of predicting soil strength based on one-pass rut depth caused by military ground vehicles. This method can be used to predict the ability of a particular forward-area airfield to sustain specific small aircraft traffic. It is recommended that further studies include operations of aircraft from actual landing sites on both clay and sand.

KEYWORDS: Military vehicles; Mobility; Soil strength; Unsurfaced airfields

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

SOIL STRENGTH CRITERIA FOR OPERATION OF FIGHTER AIRCRAFT ON UNSURFACED AIRFIELDS: BARE BASE SUPPORT; PROJECT 3782-65

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Donald M. Ladd

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1970	62	13

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 3782-65 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper S-70-24 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 158

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Air Force

13. ABSTRACT

The purpose of this study was to obtain necessary data to validate or modify, if necessary, existing soil strength criteria for the operation of high-performance jet fighter aircraft on unsurfaced airfields. Two specially prepared test sections were constructed with four test items in each section. Test section 1 consisted of two lean clay test items and two heavy clay test items. Test section 2 consisted of four items: clayey sand, lean clay, silt, and heavy clay. These test sections were trafficked with an F-4C-type loading, and the results were used to obtain criteria for operation of fighter-type aircraft on unsurfaced soils. Skid tests were also conducted on these test sections to simulate the effects of braking on unsurfaced soils. Results of the traffic tests indicated that existing criteria are adequate for use in designing unsurfaced airfields for the rolling loads of fighter aircraft. Analysis of the skid test data indicates that unsurfaced airfields constructed of soils with strength that is primarily dependent on the angle of internal friction may not be adequate to withstand maximum braking loads of fighter aircraft.

KEYWORDS: Bare base support; Fighter aircraft; Soil strength; Unsurfaced airfields

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE EFFECTS OF GEOLOGICAL FEATURES ON SOIL STRENGTH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Ellis L. Krinitzsky

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1970	72	1

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 4A061101A91D c. Item A1 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper S-70-25 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 756 159

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Assistant Secretary of the Army (R&D) Department of the Army Washington, D. C.

13. ABSTRACT

X-ray examinations of fine-grained soils from the Lower Mississippi Valley revealed numerous geologic features that are not visible to the unaided eye. These features include significant fracture patterns, details of planar bedding, cross-laminations and turbulence, secondary mineralizations, root penetrations and voids left by roots, the presence of disseminated organic matter, and other details. These geologic features affect the strength properties of the soils in which they occur. Experiments with multiple specimens from single samples embodying different features demonstrated that many large variations in strength properties were not only directly dependent on these features but were predictable in a relative sense. Normally, these features are never identified during routine soils testing although the effects of these features contribute to erratic test results. Pretest radiographic examination is a potential means of avoiding these problems.

KEYWORDS: Fine grained soils; Laboratory tests; Soil properties; Soil strength; X-rays; [Lower Mississippi Valley]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
STANDARD PENETRATION TEST AND RELATIVE DENSITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Klaus-Jurgen Melzer

6. REPORT DATE February 1971	7a. TOTAL NO. OF PAGES 10	7b. NO. OF REFS 15
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-71-1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	

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11. SUPPLEMENTARY NOTES Paper to be presented at Fourth Pan American Conference on Soil Mechanics and Foundation Engineering, San Juan, Puerto Rico, 14-18 June 1971, Proceed., Vol II.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT
Since ground water greatly influences penetration resistance of soil, an empirical relation was established between the number of blows applied in the standard penetration test to sand below ground-water level and the corresponding number applied to air-dry sand at the same relative density. Also, since the number of blows was found to depend not only on the relative density but also on the compactibility and the grain size of the penetrated sand, an empirical relation was developed between the number of blows and the relative density, with compactibility and mean grain diameter taken into account. This relation was verified by results from laboratory tests conducted with a small static penetrometer.

KEYWORDS: Penetrometers; Sands; Soil density; Soil density measuring devices; Soil penetration tests; Unit weight determination

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1. ORIGINATING ACTIVITY *(Corporate author)* U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EVALUATING PENETRATION TESTS IN CLAY FROM MEASURED SOIL PARTICLE MOVEMENTS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*

Y. T. Chou

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

The deformation and flow characteristics of a near-saturated fat clay under penetration were studied. Penetrations were made in a 50.8-cm-diam mold with a circular cone, a circular plate, and two rectangular plates at speeds ranging from 0.004 to 5.6 cm/sec. The strain, strain rate, and velocity fields in the soil were calculated from the soil particle movements, determined by measuring the displacement of pellets embedded in the soil before penetration. Actual soil flow patterns determined from velocity fields were studied. It was found that if the deformation energy of the soil were assumed equal to the penetration energy, the former could be obtained by integration over the affected volume of the deformed soil. The penetration resistance was thus computed on the basis of the Von Mises yield criterion and compared with the measured penetration resistance. Computed and measured penetration resistance values were markedly different; this casts some doubt on the applicability of the Von Mises equation to results of tests on clay under penetration and on the computational procedure employed.

KEYWORDS: Clays; Laboratory tests; Penetration resistance (Soils); Penetrometers; Soil penetration tests

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
THE PERFORMANCE OF TWO BOEING-GM WHEELS (GM VII AND GM VIII) FOR THE MANNED LUNAR ROVER VEHICLE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Andrew J. Green
Klaus-Jurgen Melzer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.

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9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for Public Release; Distribution Unlimited

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

Two candidate wheels for the Boeing-GM Manned Lunar Rover Vehicle, one fabric-covered and one constructed of open-wire mesh, were tested for mobility performance in a fine sand. Four levels of sand strength, representing cohesion values ranging from zero to 0.16 psi, were used in the tests. The cohesional and frictional properties of the sand spanned a range that is believed to include the probable range of lunar soil properties.

A dynamometer system was used to conduct programmed-slip tests with the wheels. The slip was varied from a negative slip of 15% to a positive slip of 100%. The wheels were tested at the average design load (59 lb) and at 75 and 125% of that load, so the insluence of load imbalance and dynamic load transfer could be assessed. The average speed at 0 percent slip was 3 ft/sec.

The test results show that the covered wheel was able to achieve the desired tractive performance (pull/weight ratio = 0.47, equivalent to climbing a 25-deg slope) in the two strongest soil conditions, but not in the two weakest ones. The open wheel was not able to achieve this tractive performance in any of the soil conditions tested. In the same soil condition, the maximum pull/weight ratio for the open wheel was consistently less than that for the covered wheel.

KEYWORDS: Lunar roving vehicles; Sands; Soil-wheel interaction; Wheels; [Boeing-GM Lunar Rover Vehicle]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
EVENT DIAL PACK; PROJECT LN309: EFFECTIVENESS OF CRATERS AS BARRIERS TO MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Claude A. Blackmon
Adam A. Rula

6. REPORT DATE March 1971	7a. TOTAL NO. OF PAGES 58	7b. NO. OF REFS 8
8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-71-4	
b. PROJECT NO.		
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
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10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Published in Event Dial Pack Symposium Report, Vol II, Project LN 309, Mar 1971.	12. SPONSORING MILITARY ACTIVITY Defense Atomic Support Agency Washington, D. C.

13. ABSTRACT
Event Dial Pack, a 500-ton spherical TNT charge tangent to ground surface, was detonated on 23 July 1970 at the Defence Research Establishment, Suffield (DRES), Ralston, Alberta, Canada. Project LN309: "Effectiveness of Craters as Barriers to Mobility," was included in the program of United States sponsored projects pertaining to the event. The objective of Project LN309 was to determine the degree to which a crater and its associated ejecta field constitute a physical barrier to the movement of military vehicles. Four terrain units in the crater and ejecta area were delineated as significant to ground mobility and described in terms of soil strength, soil moisture content, surface configuration, ejecta depth, and areal extent. Performance test data obtained with an M37 3/4-ton truck and an M113A1 armored personnel carrier were used to determine performance degradation in each terrain unit. Vehicle performance in the terrain units identified was predicted using the necessary elements of the Waterways Experiment Station analytical model for predicting off-road vehicle performance, and measured and predicted values for four performance parameters (drawbar pull, go-no go, motion resistance, and speed) were compared. The accuracy of the predictions was acceptable for all performance parameters except that the speeds predicted for the terrain unit (outer lip) that provided the least resistance to motion were higher than the measured values.

KEYWORDS: Crater ejecta; Craters; Explosion effects; Military vehicles; Mobility; Obstacles; Performance predictions; Personnel carriers; Terrain analysis; Trucks; [Dial pack (Event)]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP
3. REPORT TITLE UTILIZATION OF SYNTHETIC SOILS IN ENGINEERING RESEARCH	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final report	
5. AUTHOR(S) (First name, middle initial, last name) Andrew J. Green	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Assistant Secretary of the Army (R&D), Department of the Army, Washington, D. C.	

13. ABSTRACT

This report summarizes published results and personal comments of a number of researchers who have used synthetic soil mixtures. It also contains a small amount of data collected at the Waterways Experiment Station. In general, it can be said that whereas synthetic soils may be useful in some limited sense, they do not offer the panacea that earlier researchers claimed or hoped for. The engineering properties of many synthetic mixes may be more dependent on temperature and rate of loading than those of soil-water mixes. It is concluded that the usefulness of synthetic soils in engineering research is rather limited, and it is recommended that any researcher thoroughly study the behavioral patterns peculiar to a particular synthetic mix he may plan to use lest the utility of the information produced be restricted by them.

KEYWORDS: Engineering research; State-of-the-art studies; Synthetic soils

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
AUTOMATION OF CROSS-COUNTRY LOCOMOTION MODEL

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Judith A. Parks
Jack K. Stoll

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO b. PROJECT NO. 4A663712D860 c. Task 04 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-71-7 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia

13. ABSTRACT
This report explains how the user can operate the cross-country locomotion model in a conversational mode using a teletype connected to a GE-435 computer. The analytical model permits the user to predict the performance of any specified conventional ground-contact vehicle over any selected terrain in terms of average speed in miles per hour, average fuel consumption in gallons per mile, and delivery rate in ton-miles per hour. The computer code, written in FORTRAN IV, consists of a main program and three subroutines. The first subroutine, AREAL, considers terrain characterized by a specific combination of slope, soil strength, and homogeneous distributions of trees and microgeometry features; the second subroutine, LINEAR, considers elongated depressed features such as streams, ditches, etc.; and the third subroutine, SPECIF, considers surface irregularities of uniform or nonuniform size, shape, and spacing. Use of the main program and three subroutines is demonstrated by examples. These examples were obtained by utilizing data files compiled for five military vehicles and terrains selected from data files or input as requested by the subroutines. The user has the option to substitute new values for selected vehicle characteristics as an aid in vehicle design studies.

KEYWORDS: Computerized models; Military vehicles; Mobility models; Performance predictions

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
EFFECT OF DESIGN CHANGES ON VEHICLE PERFORMANCE; A LIMITED STUDY OF THE M35A2 (MODIFIED) AND THE M113A1

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

6. REPORT DATE
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C.

13. ABSTRACT

The AMC Analytical Model for Predicting Cross-Country Vehicle Performance was used in this study to investigate the effects of design changes on performance of existing vehicles. Two existing vehicles were examined in 30 different terrain units. The two vehicles selected were the M35A2 (modified) 6x6 2-1/2-ton truck and the M113A1 armored personnel carrier. Arbitrary design changes that were made on four principal vehicle characteristics--gross weight, size of tires or track, suspension system, and power plant--resulted in a total of 18 different vehicle versions, 9 wheeled and 9 tracked. The 30 terrain units, 20 in fine-grained soils and 10 in coarse-grained soils, represented a fairly wide range of terrain conditions. The data and analyses demonstrated the ability of the analytical model to predict the effects of specific design changes and showed how the effects varied with terrain conditions. Hence, the study showed that a knowledge of the terrain is essential to the evaluation of any design change. The study also pointed out that rarely will one design change improve the performance of a vehicle in all terrain conditions and that the model can be used as a design tool to specify the scope of terrain in which a vehicle may be expected to operate. The study demonstrated the improvement in performance to be expected in some terrains from a design change, but it also pointed out the degradation of performance in other terrain conditions.

KEYWORDS: Military vehicles; Mobility models; Off-road mobility; Performance predictions; Personnel carriers; Terrain; Trucks; Vehicle design; [M35A2 (Vehicle); M113A1 (Vehicle)]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

OPERATIONS AND MAINTENANCE MANUAL FOR A SCALE-MODEL LUNAR ROVING VEHICLE

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (First name, middle initial, last name)

Allan S. Lessem

6. REPORT DATE April 1972	7a. TOTAL NO. OF PAGES 59	7b. NO. OF REFS 5

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. NASA - Defense Purchase Request No. H-72026A d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-72-3 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 757 392

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY George C. Marshall Space Flight Center National Aeronautics and Space Administration, Huntsville, Alabama

13. ABSTRACT

A one-sixth scale model of the Lunar Roving Vehicle used in the Apollo 15 mission was built and instrumented to conduct model studies of vehicle mobility. The model was free running under radio control and was equipped with a lightweight telemetry transmitter that allowed 16 channels of data to be gathered simultaneously. String payout and fifth-wheel devices were developed to measure vehicle velocity. Other real-time measurements included wheel torque, wheel speed, center-of-gravity accelerations, and steering forces. Calibration, operations, and maintenance procedures were worked out. Details of the development of the instrumentation, its maintenance, some of the problems encountered, etc., are recorded in this report to serve as a preliminary operations and maintenance manual for this specific model. In addition, information regarding soil processing and testing that may be useful to NASA personnel planning mobility research with the model in soil is furnished.

KEYWORDS: Laboratory tests; Lunar roving vehicles; Mobility; Scale models

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EVALUATION OF SURFACE SHEAR STRENGTH MEASUREMENTS FOR USE IN LABORATORY MOBILITY STUDIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Thomas R. Patin

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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T062103A046, Task 03 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-72-5 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 743 167

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Laboratory tests were conducted to determine which method of obtaining five different soil-to-rubber shear measurements with two rotary-shear devices, a Cohron sheargraph and a spline shear device, would produce the most consistent measurements or quantitative indexes of surface soil strength. The tests were made at 34.5-, 68.9-, and 103.4-kN/m^2 normal pressures on a fat clay whose surface moisture content ranged from 26.5 to 45.9 percent. It was found that peak shear measurements for the full range of soil strengths used could be obtained only at the normal pressure of 34.5 kN/m^2 because of excessive sinkage of the shear head at the higher normal pressures in the softer soils. The peak shear measurements with the Cohron sheargraph, with an in-air calibration, at a normal pressure of 34.5 kN/m^2 were the most consistent and are recommended for further study to determine their validity in surface condition-vehicle performance research.

KEYWORDS: Laboratory tests; Mobility; Soil strength test instruments; Surface soil strength

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

NOTES ON PROVING RINGS AND FRAMES FOR SOIL TESTING EQUIPMENT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Mikael J. Hvorslev

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers Washington, D. C.

13. ABSTRACT This report presents data on the design, construction, and calibration of various types of proving rings and frames used for determination and direct readout of forces or loads in laboratory and field tests on soils and other relatively weak materials. The first part of the report presents equations and diagrams for determination of deflections and moments in thin circular rings, ring segments with bosses, elliptical rings, flattened rings, rectangular proving frames with thin or thick end sections, and compound cantilevers. Some of these equations can be found in handbooks and textbooks, but other equations are not readily available and were developed by applying standard methods of the theory of elasticity to relatively thin structures. The second part of the report deals with the influence of several secondary factors, such as large deformations which can cause appreciable curvature of the calibration diagrams. Rigorous equations for thick rings yield data on corrections for relatively thick devices. Empirical data on fillets and stress concentrations are presented, and the approximate stiffening effect of fillets is estimated by use of a simplified theory in which only angular deflections caused by moments are considered. The influence of misalignment, creep and hysteresis, and temperature variations is discussed briefly. The last two parts of the report present examples of single and compound proving rings and frames proposed for use or actually used in testing equipment. General design procedures using the basic equations are proposed, and data are presented on suitable materials, including recent alloy steels capable of age or precipitation hardening, which eliminates the distortion often caused by heat treatment and quenching of other steels. The final sections deal with rough calibration before hardening and final machining and corrections of dimensions if needed, which are followed by repetitive loading to slightly above the rated capacity before the final calibration in order to decrease the effects of hysteresis and creep and the possibility of zero shifts.

KEYWORDS: Penetrometers; Soil strength test instruments

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

RELATIVE SURFACING REQUIREMENTS FOR CONTAINER-HANDLING VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Donald N. Brown Richard J. Lacavich
A. A. Clark Edgar S. Rush

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8a. CONTRACT OR GRANT NO. b. PROJECT NO. 4A0662013A859 c. Task 01 d. Work Unit 011	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper S-72-34 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 905 195L	

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers, U. S. Army Washington, D. C.

13. ABSTRACT

This paper presents techniques for analyzing relative surfacing requirements for container-handling equipment. Its primary object is to emphasize the importance of evaluating the effects of vehicle characteristics on surfacing requirements prior to procurement of specific vehicles. At the present, cross-country mobility and the effect that vehicles have on bridges are the only military engineering considerations that have had a major influence on equipment design and selection. Container-handling equipment is broken down into five major categories: forklifts, straddle carriers, yard gantries, mobile cranes, and tractor-trailers. Examples of each of these categories plus the LARC LX amphibian were evaluated for operation on four different surfaces. The Waterways Experiment Station VCI system was employed to determine their ability to operate on beaches and soils of limited strength. The criteria for operation of aircraft on unsurfaced areas were used for medium- and high-strength soils, and criteria for the design of military roads and airfields were employed in the analysis for M8A1 landing mat and flexible pavement. Results of the study indicate that exceptionally large amounts of engineering support will be required for some types of equipment such as the large mobile cranes. None of the equipment was particularly suited to beach operation although it would be possible for some items to operate with limited payloads on dense sands. The M8A1 light-duty landing mat was found to be satisfactory only for two types of equipment and for periods of limited duration. The study also pointed out the need for a better understanding of traffic patterns within container storage areas and the statistical distribution of gross container weights.

KEYWORDS: Container handling vehicles; Mobility; Off-road vehicles; Requirements; Surfacings

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

AUTOMATION OF A MODEL FOR PREDICTING SOIL MOISTURE AND SOIL STRENGTH (SMSP MODEL)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Margaret H. Smith
Marvin P. Meyer

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Topographic Laboratories Fort Belvoir, Virginia

13. ABSTRACT The soil moisture strength prediction (SMSP) model is a composite of the methods developed at the U. S. Army Engineer Waterways Experiment Station for predicting daily soil moisture contents and strengths (in terms of cone index and rating cone index) of soil layers at depths of 0-15 and 15-30 cm. Information required by the model includes soil moisture accretion and depletion relations, field maximum and minimum soil moisture contents, moisture content at start of prediction, soil dry density, soil moisture-strength relation, daily rainfall amounts, and minimum rainfall amount required for accretion. This information can be obtained from one or more of three sources: (a) directly from measurements at a specific location; (b) indirectly from estimated or averaged data derived from field measurements, literature, or empirical equations built into the model; or (c) indirectly from a surface composition group classification that closely follows the Unified Soil Classification System. The computer program for the model is written in Fortran IV conversational mode for use on a teletype connected to a Honeywell-GE (General Electric) 440 computer. Output data are stored in permanent files for use by other performance prediction models, for printing, or for input to plotting programs. The main text of the report includes a discussion of the structure, operation, use, limitations, and mathematics of the model. Appendixes A-G include detailed flow charts and listings of the computer program; listings, organization, and format of input data; examples of prediction runs and graphic displays of results; and procedures for converting output data to terms required by the airfield construction effort model.

KEYWORDS: Computerized models; Soil moisture prediction; Soil strength prediction; Terrain models (Analytical)

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

POWER REQUIREMENTS FOR WHEELS OPERATING IN FINE-GRAINED SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Klaus-Jurgen Melzer

6. REPORT DATE April 1973	7a. TOTAL NO. OF PAGES 22	7b. NO. OF REFS 4
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T162112A046 c. Task 03 d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-73-2 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 759 501	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Presented at ASAE meeting, Chicago, Ill., 11-15 Dec 1972, Paper No. 72-617	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A technique based on the U. S. Army Engineer Waterways Experiment Station mobility prediction system was developed for predicting power requirements as a function of system output (pull coefficient) for a given wheel equipped with a pneumatic tire operating on clay and in a range from towed to 20 percent slip. In addition, separate relations of system output and system input (torque coefficient) as functions of slip can be predicted. Comparisons with data from vehicle field tests show fair to good agreement between measured and predicted performance parameters.

KEYWORDS: Clays; Mobility; Performance predictions; Pneumatic tires; Soil-wheel interaction; Wheels

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
SUGGESTED METHOD FOR APPLICATION OF THE WES VCI/RCI CRITERIA TO HELICOPTERS AND RELATED GROUND SUPPORT EQUIPMENT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Edgar S. Rush

6. REPORT DATE May 1973	7a. TOTAL NO. OF PAGES 22	7b. NO. OF REFS 2
8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1T162112A046, Task 02 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-73-4 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD A017 731	

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Research, Development and Engineering Directorate, Washington, D. C.

13. ABSTRACT

This report describes a method for application of the WES VCI/RCI criteria to helicopters and related ground support equipment. Through the use of ground mobility submodels developed by WES and the soil strength requirements determined for one helicopter (CH-47A), comparative performance capabilities are determined on the basis of wheel sizes and loads and sinkage into the ground. Estimates are made of the performance requirements of the AH-56A helicopter, and the application of drawbar-pull capabilities of selected ground vehicles to towing the AH-56A are presented.

KEYWORDS: Ground support equipment; Helicopters; Rating cone index; Vehicle cone index; AH-56A helicopter; CH-47A helicopter

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

EVENT MIXED COMPANY III; PROJECT LN305: EFFECTIVENESS OF CRATERS AS BARRIERS TO MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Charles E. Green

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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Defense Nuclear Agency Washington, D. C.

13. ABSTRACT

Event Mixed Company III, a 500-ton TNT surface charge, was detonated on 13 November 1972 at Grand Junction, Colorado, near Glade Park. Project LN305, "Effectiveness of Craters as Barriers to Mobility," was included in the program of projects sponsored by the United States pertaining to the event. The objective of Project LN305 was to determine: (a) the degree to which a crater and its associated ejecta field constitute a physical barrier to the movement of military vehicles, and (b) if the crater was impassable, the amount of engineering effort required to construct a passable route for the vehicles under consideration. Five terrain units (including the original surface) in the crater area were delineated as significant to ground mobility and were described in terms of soil strength, soil moisture content, surface configuration, and ejecta depth. Go-no go mobility tests were conducted with two tracked vehicles (an M113A1 armored personnel carrier and an M60A1 tank) and one wheeled vehicle (an M561 1-1/4-ton cargo carrier). The vehicles were operated easily in all the terrain units except terrain unit 4, the crater wall. The crater wall of test lane B was impassable for all the vehicles until the steep slope (66 percent) was graded to a 47 percent slope. The grading required 12 minutes with a TD 20 bulldozer. All vehicles experienced approximately the same degree of difficulty negotiating the crater walls (terrain unit 4).

KEYWORDS: Crater ejecta; Craters; Engineering effort; Explosion effects; Field tests; Military vehicles; Mobility; Terrain analysis; [M60A1 tank; M113A1 carrier; M561 carrier; Mixed Company III (Event)]; obstacles

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Mississippi

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
PROJECT DIAMOND ORE; PHASE IIA: EFFECTIVENESS OF CRATERS AS BARRIERS TO MOBILITY

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Claude A. Blackmon
Charles E. Green

6. REPORT DATE
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9a. ORIGINATOR'S REPORT NUMBER(S)
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Office, Chief of Engineers, U. S. Army
Washington, D. C.

13. ABSTRACT

Project DIAMOND ORE Phase IIA consisted of the detonation of three 10-ton charges of aluminized ammonium nitrate slurry at different depths of burst (DOB) and stemming conditions near Fort Peck, Montana, in October 1972. The purpose of the investigation described herein was to determine the effectiveness of the three craters as barriers to the performance of an M48A2 tank. The unstemmed charge at optimum DOB that formed crater IIA-1 created a marginal condition of "go-no go" for the tank. The stemmed charge at optimum DOB that formed crater IIA-2 and the stemmed charge at approximately one-half optimum DOB that formed crater IIA-3 created definite barriers to the tank. There were indications that a more effective barrier for the tank was produced by the stemmed charge at approximately one-half optimum DOB than by the stemmed charge at optimum DOB. The time required for a D-9 tractor to make crater IIA-3 passable for the M48A2 tank was 1 hour.

KEYWORDS: Craters; Explosion effects; Military vehicles; Mobility; Obstacles; Tanks (Combat vehicles); [Diamond Ore (Project); M48A2 tank]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

ANALYSIS OF THE ABILITY OF A LASER PROFILOMETER SYSTEM TO EVALUATE UNPREPARED LANDING SITES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Lewis E. Link, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

A study was made to determine the feasibility of using an airborne laser profilometer system to rapidly appraise selected unprepared landing sites. Evaluation of terrain roughness was made in terms of microrelief, slope, and obstructions. Laser profilometer data were collected at 10 test areas that provided variations in surface geometry, vegetation cover, and other natural and man-made features. The inherent characteristics of the laser profilometer system and the extraneous noise present in the laser profilometer output prevented a direct quantitative comparison of the laser profilometer output and reference profiles of the terrain. To overcome this difficulty, a procedure was developed for interpreting the laser profilometer output to obtain an interpreted terrain profile for comparison with reference profiles. A total of 17 specific terrain features at the 10 test areas were chosen for analysis of the capabilities of the laser profilometer system. Comparisons of the dimensions of the features as measured on the interpreted terrain profiles and reference profiles showed that the height of terrain features could be measured with a probable error of ±4 in. and a maximum error of approximately 10 in. The ability of the laser profilometer system to measure terrain slope was evaluated by comparing measurements of the change in elevation over a 328-ft interval as obtained on laser profilometer outputs and photogrammetric reference profiles. The laser profilometer system did not accurately measure terrain slope in direction (+ or -) or magnitude.

KEYWORDS: Field tests; Lasers; Microgeometry; Profilometers; Terrain; Unsurfaced runway performance and evaluation

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

VEHICLE MOBILITY ASSESSMENT OF MUNITIONS TRANSFER TRUCK ON SELECTED AREAL TERRAINS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Barton G. Schreiner

William E. Willoughby

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-73-14 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD B007 716L

10. DISTRIBUTION STATEMENT

Distribution limited to U. S. Government agencies only; test and evaluation; September 1973. Other requests for this document must be referred to Air Force Armament Laboratory, Eglin Air Force Base, Fla.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Air Force Armament Laboratory Eglin Air Force Base, Fla.

13. ABSTRACT

A study was conducted to assess the probable off-road performance of a munitions transfer truck (MTT) using the U. S. Army Materiel Command Ground Mobility Model (AMC-71), which is designed to predict mobility performance of vehicles operating on off-road terrain. Performance of the MTT was assessed under three loading conditions on one off-road transect each in West Germany, Thailand, and Arizona. Results show that for the three transects, the MTT would be unable to negotiate from 2.4 to 21.5 percent of the traverse distances, depending on vehicle load and season of the year. These no-go's would be caused by traction available from the terrain being less than the vehicle required. The results also show that the speed of the MTT would be limited to 2-5 mph over most of the terrain on the three transects. Vehicle speed would be controlled chiefly by ride dynamics and acceleration and deceleration between obstacles.

KEYWORDS: Mobility; Ride dynamics; Terrain; Trucks; Vehicle performance

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Miss.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE EFFECT OF MILITARY TRANSPORTATION ACTIVITIES ON THE ENVIRONMENT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Andrew J. Green
Donald D. Randolph
Adam A. Rula

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1973	73	22

8a. CONTRACT OR GRANT NO. CERL-73-9 b. PROJECT NO. Project/Task/Work Unit No. 891-05-01-001, c. "Procedures for Evaluating Environmental Impacts of Army Military Programs" d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-73-15 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Construction Engineering Research Laboratory Champaign, Illinois

13. ABSTRACT

The study reported herein was undertaken to evaluate the impact of military transportation activities upon related environmental attributes. The military activities were related to their impact on these attributes by means of a matrix. This matrix used a scale to identify the magnitude and probability of the impact. Additionally, known mitigation and abatement practices that can be used to minimize adverse environmental impacts were identified and briefly described. The principal conclusion was that this technique provided a first approximation for assessing the effect of military transportation on the environment. It is recommended that funding be provided to: (a) exploit existing data to generate quantitative relations to be used in developing environmental impact statements and (b) finance research in those areas for which the need to quantify exists and the lack of data has been acknowledged.

KEYWORDS: Environmental effects; Military operations; Transportation

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PREDICTION OF AIRCRAFT GROUND PERFORMANCE BY EVALUATION OF GROUND VEHICLE RUT DEPTHS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Gerald W. Turnage
Donald N. Brown

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
December 1973	122	14

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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d.	AFWL-TR-73-213; AD 775 744

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Air Force Weapons Laboratory Albuquerque, New Mexico

13. ABSTRACT

Two single aircraft tires (20-20, 22-PR and 49-17, 26-PR) and three standard military trucks (M715, 1-1/4-ton; M35A2, 2-1/2-ton; and M51, 5-ton) were tested under towed (nonpowered, nonbraked) and self-powered conditions, respectively, in buckshot clay test beds whose strengths ranged from about 110 to 600 cone index. Tests included multiple passes over the prepared test beds (usually 100 passes for the aircraft tires, 10 for the trucks) at low speeds. Only single-wheel configurations were examined (i.e., outer second- and third-axle wheels of the M35A2 and M51 were removed). Curves were developed to allow soil strength (airfield index) to be estimated directly from the rut produced by single or multiple passes of any of the three trucks. These curves were developed through use of a dimensionless prediction term (tire-clay numeric N_c) that allows pneumatic tire performance to be scaled over a wide range of soil strengths, wheel loads, and tire size, shape, and deflection conditions. The same numeric was shown to be capable of describing multipass rut depth and towed coefficients for the aircraft tires, as well as multipass rut depth for the trucks. Examples illustrate how airfield index (AI) estimated from truck rut depth can easily be used with curves that describe the N_c versus rut depth and towed force coefficient relations for aircraft tires to predict multipass aircraft tire performance. Appendix A shows that values of AI estimated from truck rut depth can be converted to California Bearing Ratio values and used as input for a nomograph description of aircraft operation on unsurfaced soils.

KEYWORDS: Aircraft tires; Clays; Military vehicles; Mobility; Performance predictions; Pneumatic tires; Rut depth; Soil strength; Soil-wheel interaction; Tire performance; Trafficability; Trucks; [M35A2; M51, M715]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TERRAIN ANALYSIS FOR THE ARMORED RECONNAISSANCE SCOUT VEHICLE TEST PROGRAM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Donald D. Randolph
Claude A. Blackmon

6. REPORT DATE March 1974	7a. TOTAL NO. OF PAGES 207	7b. NO. OF REFS 4
8a. CONTRACT OR GRANT NO. b. PROJECT NO. XM800 Project Manager c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper - Unnumbered 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 776 387	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Conducted by WES and USATAC. Directed by U. S. Army Materiel Systems Analysis Agency, Aberdeen Proving Ground, Maryland	12. SPONSORING MILITARY ACTIVITY Armored Reconnaissance Scout Vehicle Project Manager U. S. Army Tank-Automotive Command Warren, Michigan

13. ABSTRACT

Two study areas (FK1 and FK2), totaling approximately 11 sq miles were selected at Fort Knox, Kentucky, for comparison with a previously mapped 60-sq-mi sample of terrain in West Germany (WGT) and as potential areas for field tests with the prototype Armored Reconnaissance Scout Vehicles (ARSV's) and comparison vehicles. Areal and linear terrain data from 119 sites, aerial photographs, and other pertinent information were used to prepare the Fort Knox terrain factor complex maps. These areal maps describe the terrain characteristics that affect vehicle performance, i.e. soil type, soil strength, topographic slope, obstacles, vegetation, surface roughness, and visibility. The linear terrain factor complex maps describe the terrain characteristics that determine "go or no-go" vehicle performance, i.e. linear feature geometry, water depth, and water velocity. The Fort Knox study areas and the West German transect were compared on the basis of general descriptions (land physical characteristics, land use, etc.), areal and linear occupancy and occurrence of terrain units and terrain mobility factors, and parameters (i.e. vehicle speed and performance diagnostics) reflecting the combined effects of the terrain upon the mobility performance of the M114A1E1 armored command and reconnaissance carrier and the M151A2, 1/4-ton truck, as predicted by the AMC-71 mobility model.

KEYWORDS: Military bases; Mobility; Reconnaissance vehicles; Temperate regions; Terrain analogs; Terrain analysis; Terrain factor maps; Trucks; [Ft. Knox, Kentucky]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A LIMITED STUDY OF THE PERFORMANCE OF AN INTERIM 3/4-TON WHEEL/TRACK CONVERTIBLE TEST RIG, HOUGHTON, MICHIGAN, AND VICKSBURG, MISSISSIPPI

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

William E. Willoughby

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Miscellaneous Paper M-74-1 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command and U. S. Army Tank-Automotive Command Washington, D. C.

13. ABSTRACT

The interim Wheel/Track Convertible Test Rig, a uniquely suspended 8x8 wheeled vehicle that uses wrap-around tracks for improved performance, was tested in a variety of terrain conditions at Houghton, Michigan, and at Vicksburg, Mississippi, and in soil bins in a facility at Vicksburg. Tests were conducted to: evaluate the feasibility of the concept, determine if the track would stay on, observe interaction at the wheel-track interface to determine any possible slippage, determine ride and handling characteristics of the Wheel/Track Test Rig, which uses powered road arm suspensions, and evaluate and compare performance of the Test Rig with that of other available vehicles in tests on trails, cross-country traverses, special terrain, and laboratory-prepared soils. The Wheel/Track Test Rig performed well in a variety of terrain conditions; generally its performance equaled or exceeded the performance of both wheeled and tracked comparison vehicles. Vehicle ride and handling characteristics were considered better than those of the comparison vehicles. Test rig performance in soil in the wheel mode was impressive: a drawbar pull/weight coefficient of 0.96 was obtained on a clay soil prepared in the laboratory to a strength of 66 RCI, and a field experimental one-pass vehicle cone index of 11 was obtained. No wheel-track slip occurred during any of these tests, including tests on soft buckshot clay in which the vehicle running gear accumulated 1600 lb of mud (on a 6700-lb vehicle). Based on these tests, the Wheel/Track Convertible locomotion system is practicable, and the ride, handling, and performance of the Wheel/Track Test Rig suggest advanced testing, following any future design modifications. Appendix A presents the plan of tests followed in program.

KEYWORDS: Field tests; Laboratory tests; Military vehicles; Mobility; Soil-track interaction; Wheeled-tracked vehicles; [Houghton, Mich.; Vicksburg, Miss.]

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1. ORIGINATING ACTIVITY (Corporate author)
U. S. Army Engineer Waterways Experiment Station
Vicksburg, Miss.

2a. REPORT SECURITY CLASSIFICATION
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3. REPORT TITLE
A PRELIMINARY STUDY OF SCALE-MODEL BULLDOZER BLADES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
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5. AUTHOR(S) (First name, middle initial, last name)

6. REPORT DATE
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Miscellaneous Paper M-74-3

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Assistant Secretary of the Army (R&D)
Department of the Army
Washington, D. C.

13. ABSTRACT

Preliminary tests of scale-model bulldozer blades were conducted to ascertain the effects of moldboard coating materials on draft forces. The use of scale models for this purpose was a fully appropriate technique. However, certain experimental difficulties, determined in retrospect, rendered the results inconclusive.

KEYWORDS: Bulldozers; Cutting blades; Scale models

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Security Classification

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: Miscellaneous Paper M-74-5	2. GOVT ACCESSION NO.: AD A017 723
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): BEACH TRAFFICABILITY TESTING WITH OFF-ROAD MATERIALS HANDLING EQUIPMENT, ANZIO BEACH, LITTLE CREEK, VIRGINIA	5. TYPE OF REPORT & PERIOD COVERED: Final report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Edgar S. Rush	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Lab (WESFV) P. O. Box 631, Vicksburg, Miss. 39180	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Mobility Equipment Research and Development Center (STSFB-HMM) Fort Belvoir, Virginia 22060	12. REPORT DATE: September 1974
	13. NUMBER OF PAGES: 97
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS (of this report): Unclassified
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Beach trafficability
Container handling vehicles
Field tests
Fork lift trucks
Mobility
Performance predictions
Tire tests
[Little Creek, Virginia]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The field test program reported on herein was conducted by the U. S. Army Mobility Equipment Research and Development Center with technical assistance from the U. S. Army Engineer Waterways Experiment Station. The objectives of the program were to (a) make a quantitative evaluation of the mobility characteristics of three rough terrain forklift trucks when operating over sand beaches, (b) validate or revise the current mobility prediction formulas to cover larger, heavier, and more powerful vehicles, and (c) establish specific

design relations for vehicles being developed for materials handling, which will ensure the attainment of the required mobility. Maximum drawbar pull, maximum slope negotiable, and towed motion resistance tests were conducted on the beach backshore and dune areas. Sand data such as cone index, surface slope, and classifications were collected with each test. Numerous tire inflation pressure and axle load variations were tested for each vehicle. Standard-ply and radial-ply tires also were tested. Measured vehicle performance was compared to performance predicted by using existing mobility prediction formulas. The analysis of these comparisons indicates that changes are not needed in formulas to predict maximum drawbar pull, maximum slope climbing capabilities, or towed motion resistance. An adjustment factor for radial tires is indicated for all prediction formulas. The analysis also indicates that research needs to be conducted to determine effects of unequal axle loads and different inflation pressures, front and rear, on performance.

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Mississippi U. S. Army Tank-Automotive Command, Warren, Michigan	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY VALIDATION TEST RESULTS FOR THE ARMORED RECONNAISSANCE SCOUT AND COMPARISON VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

William E. Willoughby
Barton G. Schreiner

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Directed by U. S. Army Materiel Systems Analysis Agency Aberdeen Proving Ground, Maryland	Armored Reconnaissance Scout Vehicle Project Manager U. S. Army Tank-Automotive Command Warren, Michigan

13. ABSTRACT

Tests were conducted with the Armored Reconnaissance Scout Vehicle (ARSV) candidate wheeled and tracked vehicles and four comparison military vehicles at Aberdeen Proving Ground (APG), Maryland, and Fort Knox, Kentucky. The ARSV wheeled (XM800W) and tracked (XM800T) vehicles and the Lynx Canadian Armored Command and Reconnaissance Carrier, the M114A1E1 Armored Command and Reconnaissance Carrier, and the M551 Armored Reconnaissance/Airborne Assault Vehicle were tested at three APG sites. Two areas were selected at Fort Knox for testing with the two ARSV vehicles, the M551, and the M113A1 Armored Personnel Carrier. Tests were conducted to validate the AMC-71 Ground Mobility Model (AMC-71) at the submodel and model levels through submodel tests, terrain unit tests, and traverse tests. Tests were conducted at the submodel level of AMC-71 to develop required ride and obstacle dynamics relations for each vehicle and to validate relations in the soil submodel of AMC-71. Where necessary, the soil submodel test results were used in making adjustments to better predict speed performance at the AMC-71 model level. For the dynamics submodel, relations developed in this study indicate that the ride characteristics of the XM800W over stable ground roughness and over rigid obstacles are better than the ride characteristics of the XM800T, and, in turn, both vehicles are better than any of the comparison vehicles. To improve prediction accuracy for the XM800W from the soil submodel, traction and motion resistance relations were adjusted to compensate for the effects of radial-ply tires on vehicle performance. After this adjustment for the XM800W, the present soil submodel relations for all the vehicles were used to compute vehicle speeds at the model level for terrain units and traverses. Results of most terrain unit tests show the overall accuracy of predicted vehicle speed for the present is at an acceptable level. Tests in forested terrain units, however, where maneuvering and tree override control vehicle speed, show predicted speed was consistently higher than measured speed, indicating changes are needed in these relations to improve predicted speed accuracy of AMC-71. In comparative traverse tests the prediction accuracy for the M113A1 was the best, followed in ranking by the XM800W, XM800T, and the M551.

KEYWORDS: Armored vehicles; Military bases; Military vehicles; Mobility; Performance predictions; Reconnaissance vehicles; Ride dynamics; [Aberdeen Proving Ground, Maryland; Armored Reconnaissance Scout Vehicle; Fort Knox, Kentucky]

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper M-74-7	2. GOVT ACCESSION NO. AD A018 289	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CHARACTERIZATION OF SELECTED ROAD SECTIONS IN WESTERN UNITED STATES		5. TYPE OF REPORT & PERIOD COVERED Unclassified
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Adam A. Rula James H. Robinson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Mobility and Environmental Systems Laboratory U. S. Army Engineer Waterways Experiment Station P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project 415-920-01-37-097 Order 0607-R5-74
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Department of Agriculture, Forest Service Washington, D. C. 20250		12. REPORT DATE September 1974
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Roads
Subgrades
Tires
Unsurfaced roads
Wear tests
[Nevada]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Data were collected by the U. S. Army Engineer Waterways Experiment Station to characterize sections of gravel roads and courses selected for testing in conjunction with a U. S. Department of Agriculture, Forest Service, tire wear-road deterioration study. The primary purpose of the study reported herein was to describe, in quantitative terms, the surface and subgrade of selected sections of unpaved road surfaces in Oregon representative of logging roads in the western United States. Data also were collected on one road and one test

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

course in Nevada. Data summaries are presented in tables. Table 1 lists road data associated with the vehicle tire wear-road deterioration tests, and table 2 presents additional data for a lesser number of selected road test sections and one test course. The data include identification of surface type according to the Forest Service scheme; values of gravimetric and nuclear moisture content and density; volume, depth, and moisture content of loose surface materials; soil strength in terms of California Bearing Ratio and cone index; and material classification according to the Unified Soil Classification System. The results indicate that the road sections selected for the tire wear-road deterioration study represent a fairly wide range of surface characteristics for which data were collected. Observations revealed that the maximum safe speed that could be attained on the roads by the test vehicles was controlled primarily by curvature-visibility, grade, and roughness, in that order. It is recommended that road deterioration and performance criteria be established, and that tire wear and/or road deterioration state-of-the-art studies be conducted, including the formulation of first-generation analytical engineering model(s) to account for pertinent tire wear, road deterioration, and vehicle-road interactions in a systematic manner. Appendix A presents results of tests conducted to measure the ride quality of two vehicles used by the Forest Service in logging operations. Appendix B sets forth the study requirements as defined by the Forest Service.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper M-74-8	2. GOVT ACCESSION NO. AD A001 520	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MAPPING OF SELECTED ARSV TEST COURSES AT FORT KNOX, KENTUCKY, AND COMPARISON WITH OTHER SELECTED TERRAINS		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Donald D. Randolph		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Materiel Systems Analysis Agency Aberdeen Proving Ground, Maryland 21005		12. REPORT DATE October 1974
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Military bases	Terrain analogs	[W. Germany]
Military vehicles	Terrain analysis	
Mobility	Terrain factor maps	
Temperate regions	[Fort Knox, Ky.]	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Two test courses (FKDC and FKNC) at Fort Knox, Kentucky, totaling approximately 37.4 miles of roads and trails that had been used for conducting vehicle tests with Armored Reconnaissance Scout Vehicles (ARSV's) and comparable vehicles, were mapped by techniques developed by the U. S. Army Engineer Waterways Experiment Station. The factors mapped were soil type, soil strength, topographic slope, obstacles, surface roughness, and visibility. Standing vegetation was not present on any of the trails. The study also included
(Continued)

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

a limited comparison of the two test courses (FKDC and FKNC) with other Fort Knox terrains (FK1, FK2) and West Germany terrain (WGT). FK1, FK2, and WGT were mapped in previous studies on the basis of the single factors used to describe these test courses, i. e. soil strength, slope, surface roughness, obstacle magnitude, and visibility. It was concluded that the surface strengths of FKDC and FKNC are greater than those of FK1, FK2, and WGT. The slopes in FKDC and FKNC are similar to those in FK2 and WGT. The surface roughness and obstacle magnitude are greater in FKNC than in any of the other areas. The obstacle vertical magnitude factor classes are greater for FKNC than for FKDC or WGT. The visibility is somewhat similar and quite good in all the areas considered. Based on the five factors considered (soil strength, slope, surface roughness, obstacle vertical magnitude, and visibility), FKDC is more similar to WGT than is FKNC, and FKNC is more similar to FK2 than to FK1, FKDC, and WGT. It is recommended that the AMC-71 Mobility Model be used to compare speed performance of the ARSV vehicles and comparison vehicles over the test courses.

Unclassified

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M,E

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER DNA PR 0008	2. GOVT ACCESSION NO. AD A011 493	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PROJECT ESSEX I Phase 1, Mobility Experiments		5. TYPE OF REPORT & PERIOD COVERED Final report covering period from August-October 1973
		6. PERFORMING ORG. REPORT NUMBER Miscellaneous Paper M-75-3
7. AUTHOR(s) Charles E. Green		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Mississippi 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DNA Subtask L19EAXSX301, Work Unit 002; and DA Project 4A162118A880, Task 04, Work Unit 002
11. CONTROLLING OFFICE NAME AND ADDRESS Defense Nuclear Agency, Washington, D. C. 20305; and Office, Chief of Engineers, U. S. Army, Washington, D. C. 20314		12. REPORT DATE April 1975
		13. NUMBER OF PAGES 92
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U. S. Army Engineer Waterways Experiment Station Explosive Excavation Research Laboratory P. O. Box 631, Vicksburg, Mississippi 39180		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Crater ejecta	Military vehicles	Terrain
Craters	Mobility	[ESSEX I (Program)]
Explosion effects	Obstacles	[Fort Polk, La.]
Military bases	Performance predictions	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Project ESSEX I, Phase 1, consisted of the detonation of three 11,249-kilogram (12.4-ton) charges and one 8,981-kilogram (9.9-ton) charge of gelled nitromethane at different depths of burial and stemming conditions at the Peason Ridge Artillery Range of Fort Polk, Louisiana, at intermittent periods from 23 August to 31 October 1973. Mobility experiments were conducted to determine the degree to which the craters and their associated ejecta fields constitute a physical barrier to the movement of military vehicles. Four terrain

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

units in each crater and ejecta area were delineated as significant to ground mobility and described in terms of soil strength, soil moisture content, surface configuration, ejecta depth, and areal extent. The test vehicles (i.e. the M60 tank, the M113A1 armored personnel carrier, and the M715 cargo truck) could operate with ease in all the terrains except the crater walls (Terrain Unit 4) and the crater floors (Terrain Unit 5). The crater walls were impassable for all the test vehicles because of steep slopes, and the crater floors of all the craters were impassable for the M60 and M715 because of soft soil conditions. The M113A1 could operate on the crater floors of all the craters except the 12-MS. The engineering effort (time required by a D8 bulldozer) to make the craters passable for the test vehicles was 2.33 hours on the 12-MS crater, 3 hours on the 12-MPS crater, 2.17 hours on the 6-MS crater, and 3 hours (estimated) on the 6-MU crater. Degradation of vehicle performance in terms of drawbar-pull coefficient and speed increased for all three test vehicles in each terrain unit from the original surface to GZ. On the basis of degraded area per charge yield, the 6-MU crater was the most effective for all three test vehicles. The 12-MPS crater was the least effective for the M113A1, and the 12-MS crater was the least effective for the M60 and M715. Vehicle performance in the terrain units was predicted using the U. S. Army Materiel Command Ground Mobility Model (AMC-71) for predicting off-road vehicle performance, and measured and predicted values for four performance parameters (drawbar pull, go-no go, motion resistance, and speed) were compared. The accuracy of the predictions was acceptable for all performance parameters except vehicle speed in the cratered areas.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper M-75-4	2. GOVT ACCESSION NO. AD B005 325L	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) TERRAIN DESCRIPTION, VEHICLE MOBILITY, AND COVER AND CONCEALMENT CHARACTERISTICS FOR THE BUSHMASTER MIDDLE EAST AND EUROPE SCENARIOS: A QUALITATIVE ASSESSMENT		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Harold W. West Barton G. Schreiner		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Bushmaster Task Force Headquarters, U. S. Army Training and Doctrine Command, Fort Monroe, Va. 23651		12. REPORT DATE May 1975 13. NUMBER OF PAGES 31
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U. S. Government agencies only; test and evaluation; May 1975. Other requests for this document must be referred to Bushmaster Task Force, Headquarters, U. S. Army Training and Doctrine Command, Fort Monroe, Va.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computerized simulation	Mobility	Bushmaster (Weapons system)
Concealment	Performance predictions	Middle East
Desert regions	Temperate regions	West Germany
Military operations	Terrain analysis	
Military vehicles	War games	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A study was performed to provide terrain description, vehicle mobility, and cover and concealment characteristics on two 6- by 7-km areas; one in the Middle East and the other in West Germany. These data were then to be used as input to two war-game computer simulation models (the Bonder Individual Unit Action and Carmonette Models) in the overall program to perform a cost and operational analysis on the use of Bushmaster versus alternative weapon systems.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

Terrain data in terms of soil strength and ground surface roughness and predictions of vehicle speeds for six vehicles are provided. Cover and concealment estimates are also provided for a 300-cm-tall vertical target.

Unclassified

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M

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER Miscellaneous Paper M-75-5	2. GOVT ACCESSION NO. AD A013 986	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPARISON OF THE RIDE QUALITIES OF STANDARD M60A1 AND HYBRID (TUBE-OVER-BAR) M60A1E3 TANKS		5. TYPE OF REPORT & PERIOD COVERED Final report 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Newell R. Murphy, Jr. James H. Robinson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS M60 Tanks, ATTN: Tom Laforge/AMCPM 28150 Dequindre Warren, Michigan 48092		12. REPORT DATE June 1975 13. NUMBER OF PAGES 78
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computerized models
Military bases
Mobility
Off-road vehicles
Ride dynamics
Tanks (Combat vehicles)
Terrain
[Ft. Knox, Ky.]
[M60A1 tank]
[M60A1E3 tank]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Ride and shock tests were conducted with an M60A1 and an M60A1E3 tank on selected rough terrain courses in the Carpenter Test Area at Fort Knox, Ky., to compare their ride quality and determine the relative improvements in ride (if any) offered by the hybrid tube-over-bar suspension configuration on the M60A1E3 tank. The data were to provide better-quality terrain-limiting speeds for input to the DYNTACS computer model for combat effectiveness studies.
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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued)

Dynamics data in the form of linear and angular accelerations and absorbed power were obtained for both tanks at the driver's and the tank commander's positions with the main gun in the forward-free and the aft-locked positions. The tests were conducted in inclement weather on wet, muddy courses, which limited the maximum attainable speeds to about 15 mph. As a result, ride-limiting speeds were rarely attained. The data were extrapolated as necessary to develop the terrain-limiting speed relations required for computer combat effectiveness studies. However, because the reliability of the results was somewhat questionable, the basis for the evaluations focused more on direct comparisons of the various ride levels that were reached. Data, which are illustrated in the form of tables and graphs, indicate that there is no significant difference in the ride qualities of the two tanks, although the tanks' occupants insisted that the M60A1E3 gave a better ride. Other conclusions are that ride quality is not affected by rotating the main gun from the aft-locked position to the forward-free position. Also, there is no distinct difference between the vertical absorbed power at the driver's seat and that at the tank commander's observation seat; however, the sum of the vertical, fore-to-aft, and side-to-side absorbed power at the commander's observation seat may be as much as four, five, or more times the intensity at the driver's seat. Relations representing the data obtained from an earlier test program involving ride comparisons of a standard M60A1 and an M60A3 (complete tube-over-bar suspensions) tank are shown to illustrate the significant ride improvements that were attained with the tank configured with the complete tube-over-bar suspension. These data led to the belief that the complete tube-over-bar configuration offers a significant improvement in ride quality, whereas the hybrid tube-over-bar configuration provides no noticeable advantage. It is recommended that a comprehensive ride dynamics test program be conducted with an M60A1 tank, an M60A1E3 hybrid tube-over-bar tank, and an M60A3 tank to determine the relative merits of these three configurations and, furthermore, that this program receive the proper support from the appropriate agencies to ensure that the required test conditions are met.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Miscellaneous Paper M-75-7	2. GOVT ACCESSION NO. AD A012 653	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) WES PAPERS PRESENTED AT 5TH INTERNATIONAL CONFERENCE, INTERNATIONAL SOCIETY FOR TERRAIN-VEHICLE SYSTEMS; June 2-6, 1975, Detroit-Houghton, Michigan		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engi :er Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Mathematical models
Meetings
Military vehicles
Mobility
Mobility models
Ride dynamics
Terrain models (Analytical)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The four papers herein were presented at the Fifth International Conference of the International Society for Terrain-Vehicle Systems held at Detroit and Houghton, Michigan on 2-6 June 1975 by personnel of the Mobility and Environmental System Laboratory, U. S. Army Engineer Waterways Experiment Station. The papers which were also published in the the Proceedings, Volume IV, U. S. Army Mobility Evaluation Methodology, describe the current status of the methodology for evaluating the effectiveness of ground vehicles. The first paper, The U. S. Army Mobility Model (AMM-75), describes the second (Continued)

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20. ABSTRACT (Continued).

generation version of a comprehensive analytical model for evaluating the mobility of ground vehicle systems and the modifications that distinguish it from the first generation (AMC-71) version. The second paper, Terrain Modeling to Support Mobility Evaluation, describes the procedure and recent developments in terrain modeling to evaluate ground mobility. The third paper, Ride Dynamics Module for AMM-75 Ground Mobility Model, describes the computer module for simulating the ride and shock response of any rigid-framed vehicle and determining the relations necessary for input to the AMM-75 Ground Mobility Model to assess the effects of ride- and shock-limiting speeds on mobility. The fourth paper, Validation of the AMC-71 Mobility Model, describes the results of a comprehensive experimental program to validate and evaluate predictions of vehicle performance derived from the first generation (AMC-71) Mobility Model.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER Miscellaneous Paper M-75-8	2. GOVT ACCESSION NO. AD A014 273	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ESTIMATING THE PERFORMANCE CAPABILITY OF 50,000-LB-CAPACITY CONTAINER HANDLER ON BEACH AND DESERT SANDS		5. TYPE OF REPORT & PERIOD COVERED Final report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Edgar S. Rush Gary N. Durham		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Mobility and Environmental Systems Laboratory P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Mobility Equipment Research and Development Center Fort Belvoir, Va. 22060		12. REPORT DATE August 1975
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14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Beach trafficability	Sands
Container handling vehicles	Soil stabilization
Desert regions	Soil strength
Mobility	Trafficability
Performance predictions	[illegible]

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The purposes of this study were to: (a) summarize worldwide beach and desert sand conditions and relate these to probable performance capabilities of a 50,000-lb-capacity container handler (gross weight, 160,000 lb), and (b) review methods to improve the properties of beach sand to render it trafficable for wheeled vehicles having wheel loads in excess of 50,000 lb. A statistical

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. ABSTRACT (Continued).

analysis of data includes variations in soil strength that occur in dry-to-moist sands, the variations that occur according to beach location, variation between beach and desert sands, and variation between sand types. Also included is a discussion of the areal distribution of beach and desert sands on a worldwide basis, the factors affecting sand stabilization, and some of the more pertinent stabilization methods. By using verified vehicle performance evaluation procedures and methodology that considers the effects of tire inflation pressure, surface slopes, frequency of occurrences, and sand strength and type, the performance of a wheeled dozer, modified for handling containers, can be estimated on an areal basis. Practical stabilization of beach sands can be achieved by densification of the sand, by the introduction of cementing agents to increase sand bearing capacity, or by construction of temporary roadways. Current design and evaluation methods employed in stabilizing natural soils for road and airfield construction are not entirely applicable for designing expedient stabilized beach sand sections for transportation throughways. Appendix A presents a list of selected references concerning soil stabilization.

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3. REPORT TITLE

PLAN OF TESTS, TROPICAL SOIL STUDIES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Spanish translation of this report is available.	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This report describes the plans for obtaining field data on the engineering characteristics of the soils, vegetation, and topography of selected areas in Central and South America. The data will be used to develop a system for describing and classifying these engineering properties as they manifest themselves in the humid tropics. The data will also be used to develop a method for predicting the changes in moisture content and strength of surface soils that occur on either a daily or a seasonal basis, and to classify areas on the basis of similarity with respect to the engineering properties of their soils. The report discusses the meteorological and soils equipment to be used; the selection, layout, and number of test sites; and the test routines for collecting data at prediction-development and satellite sites. Appendix A presents the field instructions for daily visits and Appendix B provides instructions for computing data.

KEYWORDS: Field tests; Test plans; Test procedures; Trafficability; Tropical regions

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION [illegible] 2b. GROUP

3. REPORT TITLE

PLAN OF TESTS, TROPICAL SOIL STUDIES IN PANAMA AND PUERTO RICO

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This plan of tests is part of a comprehensive study to develop quantitative systems for describing and classifying the engineering characteristics of soils, vegetation, and topography of tropical environments, and for predicting their effects on military operations. This plan deals with obtaining information in selected humid-tropical areas in Panama and Puerto Rico. The report discusses the meteorological, soils, and electrical resistance (for soil moisture determinations) equipment to be used; the selection, layout and number of test sites; installation of equipment; and the test routines for collecting data at prediction-development and satellite sites. Appendix A discusses the field instructions for reading the fiberglas electrical resistance units; Appendix B provides instructions for computing data; Appendix C discusses procedures for determining moisture content at saturation and at 60-cm water tension; and Appendix D presents instructions for recording site descriptions.

KEYWORDS: Field tests; Test plans; Test procedures; Trafficability; Tropical regions; [Panama; Puerto Rico]

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Waterways Experiment Station Vicksburg, Mississippi	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

DESCRIPTION AND APPLICATION OF AIRFIELD CONE PENETROMETER

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

5 AUTHOR(S) (First name, middle initial, last name)

William B. Fenwick

6 REPORT DATE October 1965	7a. TOTAL NO OF PAGES 13	7b. NO OF REFS
8a CONTRACT OR GRANT NO b. PROJECT NO (FY 1966 Program Guidance - Task-01) c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Instruction Report 7 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 800 746	

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D.C. 20315

13 ABSTRACT

This report describes the airfield cone penetrometer, its use, and the application of data obtained by its use. The report includes information which will assist in solving specific trafficability problems. Also procedures are presented for using the airfield penetrometer to measure soil strength and for correlating soil strength with the number of passes that can be made by aircraft having various wheel loads and tire pressures.

KEYWORDS: Airfield cone penetrometer; Trafficability

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3. REPORT TITLE

RAPID ASSESSMENT OF SOIL STRENGTH AT AIRCRAFT LANDING SITES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

George M. Hammitt II

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Office, Chief of Engineers U. S. Army Washington, D. C.

13. ABSTRACT

This report presents a method of rapidly assessing the ability of an area to support aircraft operations. The method involves no special equipment or specially trained personnel, but is based on the interrelation of the response of ground surfaces of various strengths to vehicular and aircraft traffic. Data that allow the forecasting of the ability of an area to support aircraft traffic are tabulated herein. This ability is based on the rut depth occurring in a soil after one pass of a standard military vehicle.

KEYWORDS: Aircraft landing areas; Soil strength; Unsurfaced airfields

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3. REPORT TITLE: DETERMINATION OF IN-PLACE MOISTURE AND DENSITY BY NUCLEAR METHODS	
4. DESCRIPTIVE NOTES (Type of report and inclusive dates): Final report	
5. AUTHOR(S) (First name, middle initial, last name): Steve L. Webster	
6. REPORT DATE: April 1974	7a. TOTAL NO. OF PAGES: 23 7b. NO. OF REFS: 0
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10. DISTRIBUTION STATEMENT: Approved for public release; distribution unlimited.	
11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY: Office, Chief of Engineers, U. S. Army, Washington, D. C.

13. ABSTRACT Nuclear gages offer a rapid and accurate means for obtaining moisture and density values for a wide variety of materials. Recent advances in the design of nuclear equipment and a better understanding of the nuclear principles involved have led to increasingly widespread use of nuclear gages in earth construction control work. This report describes surface-type nuclear equipment, procedures, and various test methods used for making shallow-depth moisture and density determinations in place on soil and soil-aggregate mixtures. In general, a 6-in. direct transmission density test using a properly operating nuclear gage and an up-to-date factory calibration curve will yield test results slightly better than those of conventional density tests. The factory moisture calibration curve, however, must be checked and adjusted (if necessary) for each material tested. The nuclear test is simpler to perform than conventional tests and requires only about 15 min to obtain both a density and moisture test result.

KEYWORDS: Nuclear equipment; Nuclear methods; Soil aggregates; Soil density measuring devices; Soil moisture measuring devices; Unit weight determination; Water content determination

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER PSTIAC Report No. 1	2. GOVT ACCESSION NO. AD A011 269	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MICROTHESAURUS OF VEHICLE MOBILITY, ENVIRONMENT, AND PAVEMENT TERMS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station P. O. Box 631 Vicksburg, Mississippi 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project 1E865803M761/05
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Materiel Command AMCRD-EM Alexandria, Virginia 22333		12. REPORT DATE April 1975 13. NUMBER OF PAGES 132
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18. SUPPLEMENTARY NOTES

Prepared as a joint project of the Pavements and Soil Trafficability Information Analysis Center and Technical Information Center, USAEWES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environment terminology
Microthesauri
Mobility terminology
Pavements terminology
Subject index terms
Thesauri
Vehicle terminology

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The terms in the microthesaurus cover three major areas of interest: vehicle mobility, environment, and pavements, as related primarily to military research. Non-technical terms common to all subject areas in research and development are included to provide a complete vocabulary of concepts. The microthesaurus will become part of a larger version encompassing several subject areas of particular interest at the U. S. Army Engineer Waterways Experiment Station. The format, rules, and conventions used in this document generally follow

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those recommended by the Committee on Scientific and Technical Information (COSATI), and used in the Thesaurus of Engineering and Scientific Terms (TEST).

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER PSTIAC Report No. 2	2. GOVT ACCESSION NO. AD A018 290	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) BIBLIOGRAPHY OF PAPERS PRESENTED AT MEETINGS OR IN TECHNICAL JOURNALS ON STUDIES OF THE MOBILITY AND ENVIRONMENTAL SYSTEMS LABORATORY		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Marvin P. Meyer		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer Waterways Experiment Station Pavements and Soil Trafficability Information Analysis Center P. O. Box 631, Vicksburg, Miss. 39180		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Project 1T865803M761/05
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11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Materiel Command 5001 Eisenhower Ave., Alexander, Va. 22333		13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
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16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environment bibliography
Mobility bibliography
Trafficability bibliography
Vehicle bibliography

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents a bibliography of papers related to activities of the Mobility and Environmental Systems Laboratory of the U. S. Army Engineer Waterways Experiment Station published in technical journals, special publications, transactions, or proceedings, or presented at meetings, symposiums, or conferences from June 1955 through November 1974. A subject index is included.

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1. ORIGINATING ACTIVITY (Corporate author) Purdue University Engineering Experiment Station Lafayette, Indiana	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
APPLICATION OF AIRPHOTO PATTERN ANALYSIS TO SOIL TRAFFICABILITY STUDIES: Books 1-6, Supplements 1 and 2

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
R. E. Frost, et al

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. W-21-018-eng-633 and DA-22-079-eng-59

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9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
WES Contract Report 4-6, Books 1-6, Supp 1&2

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
The information contained herein is summarized in WES Technical Report No. 3-331, Report 6, Vols 1 and 2	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

The studies reported herein are part of a comprehensive effort begun in 1949 to develop techniques for estimating the trafficability of soil by remote means. They are devoted specifically to development of techniques for analyzing and interpreting vertical aerial photographs for soil trafficability purposes. To provide a basis for these studies, airphoto and soil trafficability data were collected in each of several representative landscapes over a period of several years by Purdue University and the Waterways Experiment Station personnel. Trafficability data were collected at sites in 33 humid climate states and 2 arid climate states. Book 1 (Application of Airphoto Pattern Analysis to Soil Trafficability Studies, Jun 51) discusses the airphoto pattern analysis procedure and the relationships between trafficability measurements and airphoto patterns. A description of regional drainage, topography, local erosion, natural vegetation, cultural practices, parent material, soil profile, and trafficability and cross country movement characteristics is presented for each of several landscapes in Books 2 (Glaciated Deposited Materials, Jun 51), 3 (Water Deposited Materials, Dec 52), 4 (Miscellaneous Materials, Jun 51), 5 (Eolian Materials, Mar 54), and 6 (Residual Materials, Jun 54). Additional information on the trafficability characteristics of the landscapes is presented in Supplement 1 (Sep 56) and Supplement 2 (Glacial Deposited Materials, Dec 57).

KEYWORDS: Airphoto interpretation; Trafficability prediction

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1. ORIGINATING ACTIVITY (Corporate author) Forest Service U. S. Department of Agriculture	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT, Progress Report No. I, Vol. I-II

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Progress report from 1 Apr - 1 Oct 1951

5. AUTHOR(S) (First name, middle initial, last name)

E. J. Dortignac and H. W. Lull

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1951	57	9

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report No. 4-8, Progress Report No. I, Vols I-II

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

Methods of predicting soil moisture content were developed for three sites in the Vicksburg area, Park, Rifle and Mound. Basic data from which to develop prediction methods consisted of a daily record of soil moisture from 1 April to 1 October 1951, for each site and concurrent data on rainfall, air and soil temperature, humidity and wind movement. Development and density of vegetation were checked periodically. Soil studies included profile descriptions and determination of texture, bulk density, moisture content at wilting point and field capacity, and soil moisture-tension relations. The soil moisture record consisted of a daily inventory of soil moisture content at 8 to 10 depths in the upper 42 in. This record was obtained with the Colman soil moisture meter and fiberglas units. Soil moisture contents were predicted at the 6- to 15-in. depth. The amount of soil moisture accretion at this depth following rainfall was found to be dependent on the relation between storm size and available storage. Depletion curves in the soil moisture record were very similar throughout the entire period. Average depletion prediction curves were developed for each 3-in. layer from 0 to 15 in. Depletion rates, in general, were exponential in form with rates of loss tending to decrease with depth. No relation was found between depletion rates and air and soil temperatures, humidity, wind and vegetation composition. The accretion and depletion methods were combined to predict soil moisture content for the period of record. Consistent agreements were obtained between actual and predicted values of soil moisture content.

KEYWORDS: Soil moisture prediction; Temperate regions; Trafficability; Vicksburg, Miss.

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1. ORIGINATING ACTIVITY (Corporate author) Forest Service U. S. Department of Agriculture	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT, Progress Report II

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Progress report from 1 Oct 51 - 1 Apr 52

5. AUTHOR(S) (First name, middle initial, last name)

H. W. Lull, et al

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1952	177	

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report no. 4-8, Progress Report No. II

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

Prediction methods for the period October 1951 to April 1952, the "Winter" season, were developed for the same three sites (Park, Rifle, and Mound, Vicksburg, Miss.) as reported in Progress Report I for the summer season. Basic data from which to develop prediction methods consisted of a daily record of soil moisture, water table records, and concurrent data on rainfall, air and soil temperatures, humidity and wind movement. Condition of vegetation was checked periodically; soils were classified. As in the summer season, soil moisture accretion during winter was found to be dependent on storm size and available storage. For the major part of the period depletion rates were markedly below summer rates. Following rainfalls that saturated the soil, one to two days were required to drain to field capacity; further depletion proceeded at a very slow fairly constant rate. Rates decreased with depth. High water tables affected accretion and helped to maintain high moisture contents. The accretion and depletion methods were combined to predict soil moisture content for the period of record. Consistent agreements were obtained between actual and predicted values of soil moisture content. Summer soil moisture depletion data in Progress Report I were reevaluated and a search of literature made to determine soil moisture depletion rates from other areas. Results of six special studies dealing with instrumentation, calibration of soil moisture units and interrelationships of soil moisture to volume weight and root concentration are reported.

KEYWORDS: Soil moisture prediction; Temperate regions; Trafficability; [Vicksburg, Miss.]

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1. ORIGINATING ACTIVITY (Corporate author) Forest Service U. S. Department of Agriculture	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT, Progress Report II

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Progress report from 1 Oct 51 - 1 Apr 52

5. AUTHOR(S) (First name, middle initial, last name)

H. W. Lull, et al

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

Prediction methods for the period October 1951 to April 1952, the "Winter" season, were developed for the same three sites (Park, Rifle, and Mound, Vicksburg, Miss.) as reported in Progress Report I for the summer season. Basic data from which to develop prediction methods consisted of a daily record of soil moisture, water table records, and concurrent data on rainfall, air and soil temperatures, humidity and wind movement. Condition of vegetation was checked periodically; soils were classified. As in the summer season, soil moisture accretion during winter was found to be dependent on storm size and available storage. For the major part of the period depletion rates were markedly below summer rates. Following rainfalls that saturated the soil, one to two days were required to drain to field capacity; further depletion proceeded at a very slow fairly constant rate. Rates decreased with depth. High water tables affected accretion and helped to maintain high moisture contents. The accretion and depletion methods were combined to predict soil moisture content for the period of record. C sistent agreements were obtained between actual and predicted values of soil moisture content. Summer soil moisture depletion data in Progress Report I were reevaluated and a search of literature made to determine soil moisture depletion rates from other areas. Results of six special studies dealing with instrumentation, calibration of soil moisture units and interrelationships of soil moisture to volume weight and root concentration are reported.

KEYWORDS: Soil moisture prediction; Temperate regions; Trafficability; [Vicksburg, Miss.]

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1 ORIGINATING ACTIVITY (Corporate author) Cornell University School of Civil Engineering Ithaca, New York	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE
AN ENVIRONMENTAL ANALYSIS OF THE FORT CHURCHILL, MANITOBA REGION, VOLS. I AND II, FOLIO

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Contract Report

5 AUTHOR(S) (Last name, first name, initial)
Cheney, Theodore A.; Beckel, D. K. Brown

6 REPORT DATE	7a TOTAL NO OF PAGES	7b NO OF REFS
30 May 1955	Vol. I, 215; Vol. II, 168	53

8a CONTRACT OR GRANT NO b PROJECT NO DA 22-079-eng-140 c d	9a ORIGINATOR'S REPORT NUMBER(S) 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report 3-15, Vols I, II & Folio

10 AVAILABILITY/LIMITATION NOTICES
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11 SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	WES

13 ABSTRACT This report is introduced with a general description of the cultural and natural features of the Fort Churchill environment. In the detailed discussions of the natural features, the area is described according to changes in climate and terrain with season. The summer and fall terrain is classified according to drainage, vegetation, and military characteristics. The winter and spring terrain is divided into two main categories; wooded and nonwooded, because of differences in type and accumulation of snow. General considerations of the Fort Churchill environment are dealt with according to problems in trafficability, navigation, and site selection. Illustrations, tables, maps, 6 appendices.

KEYWORDS: Environmental analysis; Environmental factors; Subarctic regions; Trafficability; [Fort Churchill, Canada]

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1. ORIGINATING ACTIVITY (Corporate author) Wilson, Nuttall, Raimond Engineers, Inc. Chestertown, Maryland	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

VEHICLE MOBILITY RESEARCH: A PRELIMINARY REVIEW OF MAJOR ACCOMPLISHMENTS AND CURRENT ACTIVITIES IN THE FIELD

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

C. J. Nuttall, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
October 1955	52	126

8a. CONTRACT OR GRANT NO. DA-22-079-eng-174	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Presented at meeting of WES Board of Consultants on Vehicle Mobility Research, New York, NY, 29 Oct 55	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This report reviews the history and current status of vehicle mobility research for use in providing background information in the planning and programming of Corps of Engineers activities in the field. Two previous reviews in mobility research, the Review and Evaluation of Research Related to Trafficability of Beaches, by Horonjeff, Seed, Van Til, Wiegel and Trask, published July 1953, and A Practical Outline of the Mechanics of Automotive Land Locomotion, by Bekker, published June 1955 cover the field rather completely. The review by Horonjeff and his associates is concerned largely with the situation as they found it, and is a thoroughly objective report with little interpretive criticism. The outline by Bekker is a more personal appraisal of the situation, presenting problems and approaches which reflect both the author's long and thoughtful association with off-road automotive work, and his personal philosophy as to its proper approach. Both surveys agree upon the necessity for research on the fundamentals of vehicle-soil interaction, and upon the use of relevant knowledge and techniques from related applied mechanics fields.

KEYWORDS: Mobility; State-of-the-art studies

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1. ORIGINATING ACTIVITY (Corporate author) Wilson, Nuttall, Raimond Engineers, Inc. Chestertown, Maryland	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

VEHICLE MOBILITY RESEARCH 1956; A REVIEW AND A SUGGESTED PROGRAM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

C. J. Nuttall, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1956	127	207

8a. CONTRACT OR GRANT NO. DA-22-079-eng-174	9a. ORIGINATOR'S REPORT NUMBER(S)
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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This report summarizes past accomplishments and current activity in vehicle mobility research, with emphasis upon soft ground crossing. The present report is prepared specifically for use by the Waterways Experiment Station (WES) in establishing its program of research on vehicle mobility. Several summaries and evaluations have been made by competent persons in the past few years. Head reviewed the situation from the British viewpoint in 1948, WES surveyed the field for its trafficability aspects in 1949, and Bekker covered the entire field in a series of lecture notes in 1952, which he summarized in 1954 and again in 1955. Wheeled vehicle tests were reviewed by Kelly in 1952, tire tests by Shields in 1954, and many aspects of mobility, in relation to beach trafficability, were covered in 1951 by Seed and in 1953 by Horonjeff et al. Finally, in 1955, Uffelmann summarized recent British activity. The status of research on several factors is presented and evaluated by the authors, and current programs are summarized. At the conclusion, a suggested program of further research is outlined. A reasonably complete bibliography of pertinent material is included.

KEYWORDS: Mobility; State-of-the-art studies

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1. ORIGINATING ACTIVITY (Corporate author)
Purdue University
Engineering Experiment Station
Lafayette, Indiana

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
TECHNIQUES FOR PREDICTING SOIL TRAFFICABILITY INFORMATION FROM AERIAL PHOTOGRAPHS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)
Robert D. Miles

6. REPORT DATE
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9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

This study is part of a comprehensive program of research devoted to further knowledge concerning the estimation of quantitative soil trafficability information by remote means, particularly through the correlation and analysis of aerial photographic patterns. The report discusses previous investigations in this field and factors that influence soil trafficability. Techniques are presented for photo interpretation of soils and landform elements; the effects of season and scale in inferring trafficability information are described. A two-year study was undertaken at three test areas in Indiana to test the validity of the techniques. Photo tones and texture were correlated with soil moisture and ground conditions.

KEYWORDS: Airphoto interpretation; Terrain analysis; Trafficability prediction; [Indiana]

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1. ORIGINATING ACTIVITY (Corporate author) U. S. Geological Survey, Military Geology Branch Department of the Interior Washington, D. C.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

TERRAIN STUDY OF THE ARMY TEST AREA, FORT GREELY, ALASKA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Holmes, G. William; Benninghof, William S.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
1957	287	22

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 8-97-10-004 c d	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report No 3-22, Vols 1-2

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	WES

13. ABSTRACT This report discusses environmental elements found at Fort Greely, Alaska that are both stable and variable with respect to seasonal change. The stable elements treated are topography, landforms, geology, soils, permafrost, and ground water. Elements exhibiting marked seasonal variations are wind action, soil moisture and temperature, vegetation, snow, lakes and streams. Some discussion is made of the testing and training activities at Fort Greely. The environmental factors found in the test area are evaluated for the important stable and seasonal elements, for elements common to the subarctic, for major factors which make the test area distinctive, for terrain factors represented in the test area and for the feasibility of cross-country movement. Illustrations, tables, maps

KEYWORDS: Environmental analysis; Military bases; Subarctic regions; Trafficability; [Fort Greely, Alaska]

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1. ORIGINATING ACTIVITY (Corporate author) FMC Corporation Ordnance Division San Jose, California	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE
A RESEARCH STUDY CONCERNING THE APPLICATION OF A FOURIER SERIES DESCRIPTION TO TERRAIN GEOMETRIES ASSOCIATED WITH GROUND MOBILITY AND RIDE DYNAMICS, PHASE 1: TERRAIN AND VEHICLE MODELS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Draft Report

5. AUTHOR(S) (First name, middle initial, last name)

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

Representative surface geometry profiles from those presented in the Waterways Experiment Station Technical Report No. 5-625, "Environmental Factors Affecting Ground Mobility in Thailand," Appendix E, are fitted by Fourier-series curves. Fit accuracy appears satisfactory and justifies confidence that all such microrelief profiles can be so described mathematically. The feasibility of using a Fourier-described terrain in finding the response of a vehicle traversing the terrain is confirmed by comparing the results of a digital computer program when using an arc and straight line bump description and when using a Fourier-series bump description. A simplified two-degree-of-freedom mathematical model of the M37 truck is used in this comparison. A seven-degree-of-freedom mathematical model of the M37 is made and a digital computer program developed to solve its differential equations of motion. A check is made of this program by comparing responses of the seven- and two-degree-of-freedom models to the same Fourier-defined terrain using their respective programs.

KEYWORDS: Fourier analysis; Mathematical models; Microgeometry; Mobility; Ride dynamics

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1. ORIGINATING ACTIVITY (Corporate author)

University of Illinois
Department of Civil Engineering
Urbana, Illinois

2a. REPORT SECURITY CLASSIFICATION

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3. REPORT TITLE

REPORT ON SURVEY OF LITERATURE IN CONNECTION WITH THE DYNAMIC BEARING CAPACITY OF SOILS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Narbey Khachaturian

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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9a. ORIGINATOR'S REPORT NUMBER(S)

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WES Contract Report 3-38

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

A critical survey is made of the literature on the structural dynamics of soils. Only the reports contributing to the subject matter are included. The references are presented in the following four distinct areas: (1) laboratory dynamic tests on soils, (2) field dynamic tests on soils, (3) design concepts and methods in structural dynamics, and (4) miscellaneous items of information contributing to the soil dynamics. The report contains altogether 114 entries. The important references in each group are discussed briefly.

KEYWORDS: Bibliographies; Dynamic bearing capacity; Soil strength

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M,E

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Texas Instruments, Inc. Geosciences Division Dallas, Texas	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
PHASE I, SYSTEM ANALYSIS FOR A WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS RADAR (PROJECT WESTAR); FINAL REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)
Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES 85	7b. NO. OF REFS 36
8a. CONTRACT OR GRANT NO. DA-22-069-eng-295 b. PROJECT NO. 8S-70-05-001-04 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report No. 4-96, No. 1	

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES Technical information contained herein included in WES Technical Report 3-693, Report 2, and Technical Report 3-727	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

The object of the investigation was, first, to find out if a radar can be used in a laboratory to provide data on terrain studies, and, if so, to find out whether such a radar can be made from conventional simple components and if necessary, used in an airplane. The investigation was carried out in three steps, which were (1) Radar Study, (2) Facility Design, and (3) Specimen Design. No existing radar is suitable for use both in the laboratory and in airborne operation. However, existing radars and radar components in the K_a-, X-, C-, and P-bands can be modified so as to be used in both laboratory and air. It was recommended that the radar used in WESTAR be the AN/TPS-21 or its equivalent, with required modifications. The operating variables of this radar have been used to set the specifications of the laboratory structure and the specimen containers. The specifications and results in this report constitute the recommendations for the establishment of the laboratory facility.

KEYWORDS: Laboratory tests; Radar; Radar equipment; Remote sensing; Soil tests (Laboratory); Systems analysis; Terrain analysis

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DOCUMENT CONTROL DATA - R & D

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1. ORIGINATING ACTIVITY (Corporate author) Texas Instruments, Inc. Science Services Division Dallas, Texas	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE
PHASE II, SYSTEM IMPLEMENTATION WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS RADAR (PROJECT WESTAR); FINAL REPORT AND ENGINEERING HANDBOOK

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Technical information contained herein included in WES Technical Report No. 3-693, Report 2, and Technical Report 3-727	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

Texas Instruments is assisting in the study of terrain analysis by radar in a laboratory environment. The design of the radar laboratory was established in Phase I, System Analysis, of the project. This Phase II report includes description of Phase I design and fabrication and installation of designated components of the WESTAR facility. These components are from three sources: (a) government furnished equipment, e.g. various subunits of the operational radar set AN/TPS-33; (b) Texas Instruments fabrication and model shops, e.g. the control console; and (c) commercial vendors, e.g. radar antennas. Other than system control and read-out elements, the system operates in an open-end archway 44 ft long and 100 ft wide at the base with an arch radius of 50 ft. A carriage, mounting the receiver-transmitters, a control junction box, and radar antennas, is track mounted to the arch and is capable of traversing a segment of the arch from the zenith to nearly ground level. Terrain specimens are prepared in wooden containers, track mounted on the floor of the WESTAR facility. Preliminary laboratory testing, calibration, and data collection indicate system losses are negligible, the radar system is functioning as designed and is expected to collect determinative terrain information at all radar frequencies provided.

KEYWORDS: Laboratory tests; Radar; Radar equipment; Remote sensing; Soil tests (Laboratory); Terrain analysis

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1. ORIGINATING ACTIVITY (Corporate author) Texas Instruments, Inc. Science Services Division Dallas, Texas	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

PHASE III, ANALYSIS OF RESULTS, WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS RADAR (PROJECT WESTAR): FINAL REPORT

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Technical information contained herein included in WES Technical Report No. 3-693, Report 2, and Technical Report No. 3-727	12. SPONSORING MILITARY ACTIVITY U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

The design and final installation requirements of the radar laboratory were established in Phase I and Phase II reports, respectively, (Texas Instruments, 1961 and 1963). This report completes Phase III in the study of terrain analysis by radar in a laboratory environment and, from the required interpretation, is Texas Instrument's final analysis and appraisal of Project WESTAR. The analysis discloses certain results of the measurement program, reexamines the total experimental program and supplies the basis for recommendations of future radar terrain analysis for mobility determinations. Project WESTAR is considered successful in that it has shown empirical relationships between radar reflectance and percent moisture content for sands, clays, and silts and that penetration depths and soil dielectric constants can be measured as a function of frequency and percent moisture.

KEYWORDS: Laboratory tests; Radar; Radar equipment; Soil moisture prediction; Soil tests (Laboratory); Terrain analysis; Remote sensing

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1. ORIGINATING ACTIVITY (Corporate author) Texas Instruments, Inc. Geosciences Operations, Science Services Division Dallas, Texas	2a. REPORT SECURITY CLASSIFICATION Unclassified; 2b. GROUP

3. REPORT TITLE

FINAL REPORT, WATERWAYS EXPERIMENT STATION TERRAIN ANALYSIS GAMMA (PROJECT WESTAG)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (First name, middle initial, last name)

Anonymous

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1964	154	25

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b. PROJECT NO.	
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d.	WES Contract Report No. 4-100

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

A laboratory gamma ray spectrometer has been installed at the Waterways Experiment Station, Vicksburg, Mississippi, and a program of controlled soil sample measurements has been initiated to investigate the possibilities in remotely determining soil type and trafficability parameters by the characteristics of the natural gamma ray spectra. Preliminary measurements on the Long Lake clay, Openwood Street silt, and Yuma sand have shown that the characteristic natural radioelement contents can be measured accurately and may be useful in identifying the soil type. Distortion of the gamma ray spectrum, which is caused by scattering and absorption in the interstitial moisture, shows sufficient measurable variation to offer definite promise as a basis for a future remote moisture measuring technique. Future work should include laboratory measurement of many more varieties of the major soil types to determine ranges of values within types with varying moisture content. The laboratory work should be supplemented by a carefully designed field program to investigate in-place variables not easily reproducible in the laboratory. These include variations within soil types, effects of meterologic variables, vegetation effects, and geometry modifications.

KEYWORDS: Gamma ray spectrometer; Gamma rays; Laboratory tests; Remote sensing, Soil classification; Soil moisture prediction; Soil tests (Laboratory)

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1. ORIGINATING ACTIVITY (Corporate author) Purdue University Engineering Experiment Station Lafayette, Indiana	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

STATISTICAL ANALYSES OF TRAFFICABILITY DATA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

Paul Irick

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
November 1953	28	

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10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

13. ABSTRACT

In this study a large amount of weather and trafficability data (precipitation, cone index, remolding index, soil moisture content, and soil density) collected from May 1952 to May 1953 at one 80 x 40 ft site (Crosby) at Lafayette, Indiana, were reduced to two related analyses. In the first of these the extent of sampling variation in certain of the measured variables and the degree to which their variation could be expressed in terms of functional relationships with concomitant variables were determined. In the second analysis, various explicit functional relationships were determined. In particular, the study assesses the reliability of cone penetrometer data obtained by sampling procedures, then evolves prediction equations for cone index means in terms of variables such as rainfall, soil moisture, and soil density. In a special case it was found that roughly 10 percent of cone index-mean variation must be attributed to sampling variation and that over 80 percent of the nonsampling variation could be accounted for from the relations of cone index means with rainfall and soil moisture.

KEYWORDS: Meteorological data; Soil density; Soil moisture; Soil property relations; Soil property variations; Soil strength; Statistical analysis; Trafficability data; [Lafayette, Indiana]

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1. ORIGINATING ACTIVITY (Corporate author) Wilson, Nuttall, Raimond Engineers, Inc. Chestertown, Maryland	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

OBSERVING, ANALYZING, AND FORECASTING THE STATE OF THE GROUND

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Grenke, W. C.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1965	230	1229

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d.	WES Contract Report No. 3-112

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Chief of Research and Development Department of the Army Washington, D. C. 20310

13. ABSTRACT

A study was made to determine the feasibility of developing an integrated system for observing, analyzing, and forecasting the state of the ground. The study relied chiefly on an extensive literature review, a worldwide questionnaire survey, and interviews with personnel of U. S. civilian and military agencies with an interest in the subject. It was found that the most widely useful indicators of the state of the ground were soil moisture content, soil temperature and soil strength. It was further found that while information of this type is being collected at numerous sites around the world, there is little evidence of standardization of instruments or depths and frequencies of observations. Suitable methods are presently available for developing an integrated state-of-the-ground system, but improvements in the methods are desirable. Three systems are suggested, one for international use, one for civilian use in this country, and a third for U. S. military use on a worldwide basis.

KEYWORDS: Environmental analysis; Soil moisture; Soil strength; Soil temperature; State-of-the-art studies; State of the ground; Terrain analysis

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Security Classification

DOCUMENT CONTROL DATA - R&D

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1 ORIGINATING ACTIVITY (Corporate author)
Chrysler Corporation

2a REPORT SECURITY CLASSIFICATION
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2b GROUP

3 REPORT TITLE
A STUDY OF THE VEHICLE RIDE DYNAMICS ASPECT OF GROUND MOBILITY

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report in 4 volumes

5 AUTHOR(S) (Last name, first name, initial)
Van Deusen, B. D., and Hoppe, C. H.

6 REPORT DATE
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9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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Vol 1 - AD 467 024 Vol 3 - AD 467 026
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10 AVAILABILITY/LIMITATION NOTICES
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11 SUPPLEMENTARY NOTES
Service Agency: U. S. Army Materiel Command. Conducted for: U.S. Army Engineer Waterways Experiment Station, CE

12 SPONSORING MILITARY ACTIVITY
ADVANCED RESEARCH PROJECTS AGENCY
Directorate of Remote Area Conflict

13 ABSTRACT The study was conducted in four critical elements as follows: Human Response to Vehicle Vibration (vol 2): The criterion for evaluation of vehicle vibration is that of human response to motion caused by terrain irregularities. A critical review of the literature is reported. A feasibility study was conducted to verify the possibility of measuring physical magnitudes which are correlates of the subjective ride experience in the actual vehicle environment. It is concluded that vibration acceleration variance, as a function of frequency and raised to the proper power, is a measure of ride sensation. Theoretical Dynamics (vol 3): After a critical review of the literature, two methods were selected as applicable to mathematical modeling of vehicles. A frequency domain approach is developed for detailed analysis of linear models with an output dictated by human response considerations. For nonlinear systems, the calculation is performed in the time domain with output interpreted in the frequency domain. An example of both methods for an M37 model is given. Field Measurements (vol 4): It is concluded that no automatic profile measuring device is available which gives an accurate measure of the profile information necessary for vehicle dynamics. A feasibility study was made to measure motion of an XM410 wheel. This method of profile measurement does not appear satisfactory at present, but further development is suggested. Surveying techniques seem to be the most accurate terrain measurement method available. To measure vehicle response accelerometers, properly positioned and interpreted in terms of power spectral density, should be used. Summary (vol 1): A simple method for comparing vehicle vibration over various terrain has been developed; the vehicle is specified by 3 numbers, the terrain by 2. Simple arithmetic allows an estimate of vertical vibration in each of 3 frequency bands for any given vehicle over any given terrain.

KEYWORDS: Mathematical models; Mobility; Ride dynamics; Vibration effects (Vehicles)

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1 ORIGINATING ACTIVITY (Corporate author) U. S. Army Engineer Division, Ohio River, CE Ohio River Division Laboratories Cincinnati, Ohio	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP

3 REPORT TITLE

PHOTOELASTIC STUDIES FOR VEHICLE MOBILITY RESEARCH

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name first name, initial)

Hellinger, F. H.
Hubbard, J. H.
Peters, R. L.

6 REPORT DATE	7a TOTAL NO. OF PAGES	7b NO OF REFS
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8a CONTRACT OR GRANT NO b. PROJECT NO 1-V-0-21701-A-046, Trafficability and Mobility Research c Task -03, Mobility Fundamentals and Model Studies d	9a ORIGINATOR'S REPORT NUMBER(S) 9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report No. 3-118, AD 621 221

10 AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES Conducted for: U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C. 20315

13 ABSTRACT

The test procedures and techniques developed in the studies reported herein provide a means of obtaining photoelastic stress patterns for moving wheel loads at controlled degrees of slip. Sufficient information was developed to compute normal and shear stress distribution on planes in the gelatin foundation within one-fourth inch of the contact surface between the moving wheel load and gelatin, if certain approximations are made. Further study is indicated to accurately define the stress at a point. Concerning the action of the static and moving wheel loads on the gelatin model, it was found that there was an increase in maximum shear stress for the moving wheel load at 0, +25%, and +50% slip over that of an equivalent static wheel load. This increase in maximum shear stress was due to a redistribution of normal stress at the wheel contact with the gelatin. Also, the maximum shear stress under the action of the moving wheel load was gre er at 0 slip than at +25% and +50% slip.

KEYWORDS: Gelatin models; Mobility; Photoelasticity; Stress distribution; Stresses under wheels; Wheels

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1. ORIGINATING ACTIVITY (Corporate author) Wilson, Nuttall, Raimond, Engineers, Inc. Chestertown, Maryland	2a. REPORT SECURITY CLASSIFICATION Unclassified
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3. REPORT TITLE

SUMMARY OF TRAFFICABILITY TESTS THROUGH 1963

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report in six volumes; volume 5 has 4 parts; volume 6 has 3 parts

5. AUTHOR(S) (Last name, first name, initial)

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO. OF REFS
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d.	WES Contract Report 3-119, Vols I-VI

10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES Prepared under contract with U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency Directorate of Remote Area Conflict

13. ABSTRACT

This report is essentially a compilation of available trafficability test data which were collected during testing programs conducted by or sponsored by Government agencies. Due to the large volume of pertinent information available, this report has been organized in six volumes. Volume 1 presents the background, data sources, summary of pertinent reports, and procedures used in preparing data summaries. The remaining volumes present data summaries as follows: Volume II, Vehicle Specifications; Volume III, Soil Data Sheets; Volume IV, Tire Information; Volume V, Wheeled Vehicle Test Data Sheets; and Volume VI, Tracked Vehicle Test Data Sheets.

KEYWORDS: Mobility; State-of-the-art studies, Tires; Tracked vehicles; Trafficability; Vehicle specifications; Wheeled vehicles

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Security Classification

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Security Classification

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1. ORIGINATING ACTIVITY (Corporate author)
Wilson, Nuttall, Raimond, Engineers, Inc.
Chestertown, Maryland

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE

AN EXPLORATORY STUDY OF THE EFFECTS OF TERRAIN SURFACE OBSTACLES ON VEHICLE PERFORMANCE (Final Draft)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Draft Report

5. AUTHOR(S) (Last name, first name, initial)

Cohron, G. T. and Werner, R. A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO.
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b. PROJECT NO.

c. ARPA Order No. 400

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

Contract Report No. 313-2

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

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10. AVAILABILITY/LIMITATION NOTICES

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11. SUPPLEMENTARY NOTES
Prepared under contract with
U. S. Army Engineer Waterways
Experiment Station, Vicksburg, Miss.

12. SPONSORING MILITARY ACTIVITY

Advanced Research Projects Agency
Directorate of Remote Area Conflict

13. ABSTRACT

This was the first major attempt to correlate terrain surface obstacles (lateral, longitudinal, and vertical) with vehicle performance. Purpose of the study was to develop and/or evaluate (1) measurement systems necessary to permit quantitative description of vehicle performance and the terrain on which vehicles are operated (2) test methodology including proper experimental design (3) methods of analysis leading to quantitative vehicle-performance relations (4) approximate limits for both "immobilization" and "no-effect" values of important parameters and (5) a study plan which will include an analytical framework within which more extensive future studies should be analyzed. Analysis of test data revealed the important terrain-vehicle relations for cross-country mobility and the proper methods of measuring and analyzing important terrain-vehicle parameters.

KEYWORDS: Obstacles; Obstacle-wheel interaction; Offroad mobility; Performance tests (Vehicles); Surface geometry factors; Terrain-vehicle interaction; Test procedures; Vehicle performance

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1. ORIGINATING ACTIVITY (Corporate author)
Wilson, Nuttall, Raimond, Engineers, Inc.
Chestertown, Maryland

2a. REPORT SECURITY CLASSIFICATION
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2b. GROUP

3. REPORT TITLE
A DIMENSIONLESS CONSOLIDATION OF WES DATA ON THE PERFORMANCE OF SAND UNDER TIRE LOADS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final report

5. AUTHOR(S) (Last name, first name, initial)
Nuttall, C. J., Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. DA-22-079-eng-262

b. PROJECT NO. 1-V-0-21701-A-046, Trafficability and Mobility Research

c. Task -03, Mobility Fundamentals and Model Studies

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
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10. AVAILABILITY/LIMITATION NOTICES
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11. SUPPLEMENTARY NOTES Prepared under contract for U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.

12. SPONSORING MILITARY ACTIVITY
U. S. Army Materiel Command
Washington, D. C. 20315

13. ABSTRACT

A semiempiric, dimensionless load coefficient is developed from extensive WES field and laboratory data on the performance of pneumatic tires in dry sands. The coefficient appears to collapse these diverse data to a useful degree. The physical meaning of the numeric is discussed, and its relation to some earlier work is shown. A preliminary consolidation of the data using the final form of the numeric is presented.

KEYWORDS: Dimensional analysis; Mobility numbers; Pneumatic tires; Sands; Soil-wheel interaction

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1. ORIGINATING ACTIVITY (Corporate author) Land Locomotion Laboratory U. S. Army Tank-Automotive Center Warren, Michigan	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY ENVIRONMENTAL STUDY: ONE-PASS PROGRAM

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Report

5. AUTHOR(S) (Last name, first name, initial)

Haley, Peter W.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
January 1965	22	0

8a. CONTRACT OR GRANT NO. b. PROJECT NO. c. Advanced Research Projects Agency Directorate of Remote Area Conflict d. ARPA Order No. 400	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report No. 3-143, AD 467 165

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES Conducted for the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agency

13. ABSTRACT The test program was divided into four parts, based on the conditions considered:

1. Determination of the coefficient of friction between the vehicle wheel or track and a slippery surface overlaying a hard pan of silty clay and one of Buckshot Clay, through measured vehicle tests and predicted performance.
2. Determination of the drawbar-pull vs slip curve in a fat Buckshot Clay for the vehicles tested by measured vehicle tests and predicted performance.
3. Determination of the drawbar-pull vs slip curve in a lean silty clay for the vehicles tested by measured vehicle tests and predicted performance.
4. Determination of the drawbar-pull vs slip curves for an Euclid C-6 crawler tractor in (a) a dry sand and (b) a slippery surface condition on a clay by means of a measured vehicle test and predicted performance.

These vehicle tests were performed with a single pass through the undisturbed test course. The vehicles chosen represented a wide range of standard military vehicle characteristics using a minimum number of vehicle types. The choice of vehicles included a 1/4-ton M38A-1, 3/4-ton M37, 2-1/2-ton M35A1 (modified to single 11.00-20 tires), M39C Amphibian, M115 Personnel Carrier, and a POLECAT 914 articulated steering vehicle.

The test results are discussed in terms of the accuracy of predicted vehicle performance. Particular emphasis is given to causes of differences between predicted and measured performance values.

KEYWORDS: Field tests; Military vehicles; Mobility; One-pass performance; Soil-vehicle interaction; Trafficability

DD FORM 1 JAN 64 1473

Unclassified

Security Classification

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DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1 ORIGINATING ACTIVITY (Corporate author) Wilson, Nuttall, Raimond, Engineers, Inc. Chestertown, Maryland	2a REPORT SECURITY CLASSIFICATION Unclassified
	2b GROUP

3 REPORT TITLE

ONE-PASS PERFORMANCE OF VEHICLES ON FINE-GRAINED SOILS

4 DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5 AUTHOR(S) (Last name, first name, initial)

Nuttall, Clifford J., Jr; Wilson, Charles W.; Werner, Richard A.

6 REPORT DATE	7a. TOTAL NO OF PAGES	7b NO OF REFS
July 1966	130	33

8a CONTRACT OR GRANT NO. DA-22-079-eng-394	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO.	
c ARPA Order No. 400	9b OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	WES Contract Report No. 3-152, AD 487 446

10 AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY
Prepared under contract with U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	Advanced Research Projects Agency Directorate of Remote Area Conflict

13 ABSTRACT

This report presents results of an investigation of the one-pass performance of self-propelled vehicles in natural, weak, fine-grained soils for the following purposes: (1) to develop (a) a reliable strength index for fine-grained soils with which predictions may be made of the performance of a vehicle on its first pass on a straight, level course, and (b) a nominal vehicle load index to be used with the soil strength index to establish whether or not a vehicle will go; and (2) to provide means to predict (a) one-pass drawbar pull and slope performance in soils having strengths in excess of the minimum required for one vehicle pass on level terrain, (b) the increment of soil strength index necessary to permit a vehicle to maneuver freely, and (c) the probable maximum speed of a vehicle operating in a terrain situation where the soil strength index exceeds the net vehicle load index.

First-order answers are proposed to the five basic questions utilizing minor adaptations of techniques and concepts developed by WES in their 50-pass trafficability work, and defining modified "vehicle cone indices" (VCI_1) and soil "rating cone index " (RCI_1) procedures appropriate to the one-pass problem. The calculations of drawbar pull, grade performance, soil strength increments necessary to permit free maneuvering, and probable maximum speeds, all as influenced by soil strengths.

KEYWORDS: Fine grained soils; Mobility; One-pass performance; Self propelled vehicles; Trafficability; Vehicle cone index

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Land Locomotion Laboratory U. S. Army Tank-Automotive Center Warren, Michigan	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

MOBILITY ENVIRONMENTAL RESEARCH STUDY; MOBILITY TESTING PROCEDURES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

Liston, R. A.; Czako, T.; Haley, P.; Harrison, W. L., Jr.; Hanamoto, B.; Martin, L.

6. REPORT DATE	7a. TOTAL NO OF PAGES	7b. NO OF REFS
February 1966	79	5

8a. CONTRACT OR GRANT NO. b. PROJECT NO c. Advanced Research Projects Agency Directorate of Remote Area Conflict d. Order No. 400	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report 3-153, AD 800 462

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Conducted for the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi	Advanced Research Projects Agency

13. ABSTRACT

Test procedures to be used for the evaluation of off-road vehicle mobility performance are presented. The development of a quantitative evaluation system represents an important step in the design of proper off-road vehicle tests. The procedures are presented as nine Annexes, entitled as follows: (1) Drawbar Pull, (2) Torque, (3) Vehicle Speed, (4) Vehicle Sinkage and Trim, (5) Resistance to Towing, (6) Fuel Consumption, (7) Load Distribution and Ground Pressure, (8) Determination of Land Locomotion Soil Values, and (9) Determination of WES Soil Parameters.

KEYWORDS: Mobility; Off-road mobility; Test procedures

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1 ORIGINATING ACTIVITY (Corporate author) Colorado State University Fort Collins, Colorado	2a REPORT SECURITY CLASSIFICATION Unclassified 2b GROUP
3 REPORT TITLE INSTRUMENTATION FOR VEHICLE MOBILITY TESTING IN A TROPICAL ENVIRONMENT	
4 DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report	
5 AUTHOR(S) (Last name, first name, initial) Clark, Stanley J.	

6 REPORT DATE June 1966	7a TOTAL NO OF PAGES 36	7b. NO. OF REFS 0
8a CONTRACT OR GRANT NO DA-22-079-eng-378 (Negotiated) b. PROJECT NO c Advanced Research Projects Agency ARPA Order No. 400 d	9a ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report 3-154	
10 AVAILABILITY/LIMITATION NOTICES Approved for public release; distribution unlimited.		
11 SUPPLEMENTARY NOTES Prepared under contract with the U. S. Army Engineer Waterways Experiment Station, Vicksburg, Miss.	12. SPONSORING MILITARY ACTIVITY Advanced Research Projects Agen	

13 ABSTRACT

This report highlights the accomplishments of an instrumentation team from the Colorado State University which provided technical assistance to the Advanced Research Projects Agency in Thailand. The major portion of the work load was connected with vehicle testing. During the contract period the Colorado State University Thailand Trafficability Instrumentation Team instrumented and assisted with trafficability tests of the following vehicles: Dodge Power Wagon, Vickers Hover Truck, M37 3/4-ton truck, Spryte, XM-561, Rolligon, M116, and XM571. The details of tasks involving the design and operation of instrumentation systems for research and development related to vehicular trafficability are reported.

KEYWORDS: Military vehicles; Mobility: Trafficability; Tropical regions; Vehicle test instruments; [Thailand]

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1. ORIGINATING ACTIVITY (Corporate author) FMC Corporation Ordnance Engineering Division San Jose, California	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

A COMPUTER ANALYSIS OF VEHICLE DYNAMICS WHILE TRAVERSING HARD SURFACE TERRAIN PROFILES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report

5. AUTHOR(S) (Last name, first name, initial)

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1966	199	3

8a. CONTRACT OR GRANT NO. b. PROJECT NO. 1V0-25-001-A131 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report No. 3-155, AD 803 194

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	U. S. Army Materiel Command Washington, D. C. 20315

13. ABSTRACT

This computer study has shown that ground mobility and ride dynamics can be accurately computed by using a digital computer. The study further indicates that the accuracy of the computer analysis is dependent upon the degree of care exercised in describing the vehicle and the hard surface terrain profile to the computer. The most accurate way to describe most hard surface terrain profiles is with a table of field survey data. The computer, by using table-look-up and linear interpolation, can easily compute vehicle forcing functions. The study has shown that vehicle mathematical models can be accurately developed by describing the motions of the vehicle by a series of differential equations. Actual descriptions of the vehicle and suspension are required for an accurate computer solution. The dynamic force-rate tables for the shocks and force deflection tables for the springs are important inputs to the computer program. A computer solution for vehicle ride dynamics can accurately compute vehicle responses from careful descriptions of the hard-surface terrain profile and vehicle assembly.

KEYWORDS: Computerized models; Microgeometry; Mobility; Ride dynamics

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Wilson, Nuttall, Raimond Engineers, Incorporated Chestertown, Md.	2a. REPORT SECURITY CLASSIFICATION Unclassified
	2b. GROUP

3. REPORT TITLE

GROUND-CRAWLING: 1966; THE STATE-OF-THE-ART OF DESIGNING OFF-ROAD VEHICLES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report

5. AUTHOR(S) (First name, middle initial, last name)

C. J. Nuttall, Jr.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1967	330	667

8a. CONTRACT OR GRANT NO. Contract No. DA-22-079-eng-392	9a. ORIGINATOR'S REPORT NUMBER(S)
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d.	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Conducted for U. S. Army Engineer Waterways Experiment Station, Corps of Engineers, Vicksburg, Miss.	U. S. Army Materiel Command

13. ABSTRACT

The state-of-the-art of off-road vehicle design, especially of military vehicles, is surveyed with particular reference to those design elements which especially distinguish off-road vehicles from related equipment. The procedures by which off-road military vehicles advance from concept and/or requirement to field issue are also reviewed, and some relations between apparent technical weaknesses and the administrative procedures are pointed out. It is concluded that to provide the more mobile vehicles needed by the Army in the field in Southeast Asia a complete second family of off-road military vehicles is required--an integrated, compatible system of vehicles optimized for operations in Southeast Asia rather than in Europe, as is cur present standard fleet. Organizational changes which would speed such an approach are suggested.

KEYWORDS: Military vehicles; Off-road mobility; State-of-the-art studies; Vehicle design; [Southeast Asia]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Geotech, a Teledyne Company 3401 Shiloh Road Garland, Tex.	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

RESEARCH, DEVELOPMENT, AND PROTOTYPE PRODUCTION OF AN ULTRAVIOLET SENSING SOIL MOISTURE METER

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final report, 1 March 1967-27 August 1967

5. AUTHOR(S) (First name, middle initial, last name)

Jerald B. Cohen

6. REPORT DATE August 1967	7a. TOTAL NO. OF PAGES 35	7b. NO. OF REFS
8a. CONTRACT OR GRANT NO. DACA 39-67-C-0028 b. PROJECT NO c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 67-52 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 837 529 WES Contract Report No. 3-176	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY Waterways Experiment Station

13. ABSTRACT

A research program was conducted "to determine feasibility of measuring moisture content of soils by measuring the amount of ultraviolet light transmission through moisture contained in a soil analog encased in a quartz-granule wafer emplaced in the soil." Results obtained from many combinations of soil analogs and system geometry indicate that the concept is operationally impractical. Selected instrumentation developed for the program was reapplied to pursue investigation of promising variations of the initial concept. One variation involved critical angle refractometry. Under laboratory conditions, refractometer-type systems repeatedly yielded signal outputs directly correlative with the percent (moisture) saturation of all soil samples provided. This performance was achieved independent of soil temperature and variations in index of refraction of the soil moisture. Field testing of critical angle refractometers is necessary for establishing the performance of, and specifications for, any operational units. A promising configuration for field test units was prepared.

KEYWORDS: Soil moisture measuring devices; Ultraviolet instruments

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1. ORIGINATING ACTIVITY (Corporate author) Department of Soils Oregon State University Corvallis, Oregon	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY; Volume I: DATA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume I of final report

5. AUTHOR(S) (First name, middle initial, last name)

Larry Boersma
G. H. Simonson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1970	235	14

8a. CONTRACT OR GRANT NO DA-22 079-eng-356 b. PROJECT NO 1V021701A046 and 1V025001A131 c. Task 02 d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 870 793 WES Contract Report M-70-1, Vol I

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Prepared under contract with U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.	U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Three near-modal test sites were established on each of the five soil series (Willamette, Woodburn, Amity, Concord, and Dayton) of the Willamette Catena in western Oregon. Field and laboratory tests on soils from the 15 test sites were initiated in the fall of 1963 and terminated in the summer of 1965. The objectives of the study were to (a) determine whether particular water table regimes are associated with specific soil types, (b) achieve the capability for appraising water table regimes from soil morphological information, and (c) gain background knowledge needed in the development of prediction methods for water table depths, soil moisture contents, and soil strengths. Data obtained daily at each site included maximum and minimum air temperatures, precipitation, groundwater depths, and electrical resistance measurement of soil moisture content and temperature. Data obtained periodically included gravimetric soil moisture contents, soil strengths, and the state of the ground and vegetation. Data collected at an opportune time during the course of the study included Atterberg limits, grain-size distributions, specific gravities, organic matter contents, moisture contents at specified tensions, dry densities, site descriptions, and soil profile descriptions. The data above have been condensed in tabular and graphic form for presentation herein. Also included are brief descriptions of the geology, topography, physiography, climate, soils, and land use of the study area. Corrected soil moisture unit readings and corresponding gravimetric soil moisture measurements are included in Appendix A. An analysis of the data is to be presented in Volume II of this report.

KEYWORDS: Trafficability; Water table prediction; Water tables data; [Oregon]

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(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Department of Soils, Oregon State University Corvallis, Oregon	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

CHARACTERIZATION OF WATER TABLES IN OREGON SOILS WITH REFERENCE TO TRAFFICABILITY; Volume II. ANALYSIS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Volume II of final report

5. AUTHOR(S) (First name, middle initial, last name)

Larry Boersma
G. H. Simonson
D. G. Watts

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1970	108	8

8a. CONTRACT OR GRANT NO. DA-22-079-eng-356 b. PROJECT NO. 1V021701A046 and 1V025001A131 c. Task 02 d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AD 870 796 WES Contract Report M-70-1, Vol II

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES Prepared under contract with U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi	12. SPONSORING MILITARY ACTIVITY U. S. Army Materiel Command Washington, D. C.

13. ABSTRACT

Three near-modal test sites were established on each of the five soil series (Willamette, Woodburn, Amity, Concord, and Dayton) of the Willamette drainage sequence in western Oregon. Field and laboratory tests on soils from the 15 test sites were initiated in the fall of 1963 and terminated in the summer of 1965. The objectives of the study were to (a) determine whether particular water table regimes are associated with specific soil types, (b) achieve the capability for appraising water table regimes from soil morphological information, and (c) gain background knowledge needed in the development of prediction methods for water table depths, soil moisture contents, and soil strengths. Data obtained daily at each site included maximum and minimum air temperatures, precipitation, groundwater depths, and electrical resistance measurements of soil water content and temperature. Data obtained periodically included gravimetric soil water contents, soil strengths, and the state of the ground and vegetation. Data collected at opportune times during the course of the study included Atterberg limits, grain-size distributions, specific gravities, organic matter contents, water contents at specified tensions, dry densities, site descriptions, and soil profile descriptions. These data have been presented in Volume I of the report. The analysis of the data is presented herein. Included is a frequency analysis of the occurrence of certain water table conditions. The frequency and duration of certain water table conditions are related to morphological soil profile characteristics. It is shown how water table regimes may be inferred from morphological information.

KEYWORDS: Soil analysis; Trafficability; Water table prediction; Water tables; [Oregon]

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Security Classification

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DOCUMENT CONTROL DATA - R & D

1. ORIGINATING ACTIVITY (Corporate author): The Florida State University, Tallahassee, Florida

2a. REPORT SECURITY CLASSIFICATION: Unclassified

2b. GROUP:

3. REPORT TITLE: A STUDY TO DEVELOP METHODS FOR THE ANALYSIS OF THE FINE STRUCTURE OF SEA-LAND BOUNDARY ZONES

4. DESCRIPTIVE NOTES (Type of report and inclusive dates): Contract Report

5. AUTHOR(S) (First name, middle initial, last name):
Stevenson, Robert E.
Warnke, Detlef A.

6. REPORT DATE: 31 July 1964

7a. TOTAL NO OF PAGES: 96

7b. NO OF REFS: 4

8a. CONTRACT OR GRANT NO: DA-22-079-eng-358

b. PROJECT NO

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9a. ORIGINATOR'S REPORT NUMBER(S):

9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report): WES Contract Report - Unnumbered

10. DISTRIBUTION STATEMENT: Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES: App. A, Photographs; App. B, Maps & Overlays; App. C, Profiles; App. D, Trafficability Data; App. E, Vegetation Data; App. F, Vegetation Data

12. SPONSORING MILITARY ACTIVITY: WES

13. ABSTRACT

This report is based on studies of 11 sites in the Big Bend area of northwest Florida and four sites in the Florida Keys. For each site, parallel profiles perpendicular to the shoreline and spaced at 5- to 10-meter intervals were constructed, and for most sites radial profiles at 15° intervals were also prepared. Investigations were made of surface geometry, soils trafficability, and vegetation in connection with the beach sites, using the pre-existing WES sampling techniques and descriptive systems. Contour maps, showing location of the profiles, vegetation, and locations where trafficability data were taken, were prepared for each site. A descriptive and a classification system are developed. Appendices contain large-scale contour maps and profiles of each site, trafficability and vegetational data, and aerial and ground photographs. A detailed discussion of alternative field methods used, with their relative advantages and disadvantages is presented. The following conclusions are stated: (a) The land-sea boundary zone represents a unique factor family. Setting it apart are the constant changes which it undergoes, the most important of which are tidal fluctuations, and the linearity of structural elements. (b) Most beaches and tidal flats consist of fine sand with a median diameter of 0.3 mm. Sorting on the beaches is excellent, poorer on the tidal flats. (c) Cone penetrometer readings on all the beaches are highly erratic. Tables, maps, illustrations. Six appendices.

KEYWORDS: Beach terrain; Beach trafficability; Land-water interface; Surface geometry; Trafficability; Vegetation; [Florida]

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1. ORIGINATING ACTIVITY (Corporate author) The Florida State University Oceanographic Institute Tallahassee, Florida	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

ENVIRONMENTAL STUDIES OF PROTECTED SEA-LAND BOUNDARY ZONES ALONG THE WEST COAST OF FLORIDA

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Contract Report

5. AUTHOR(S) (Last name, first name, initial)

Stevenson, Robert E.
Warnke, Detlef A.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
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8a. CONTRACT OR GRANT NO. DA-22-079-eng-358 b. PROJECT NO. c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) WES Contract Report - Unnumbered

10. AVAILABILITY/LIMITATION NOTICES

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	WES

13. ABSTRACT This report covers the study of 12 sea-land boundary sites on the western side of peninsular Florida. The sites were chosen to be representative of low-energy, marshy coasts. The report presents verbal descriptions of the sites in terms of topography, vegetation, soils, and trafficability. Detailed strip maps portraying these factors, with a "characteristic central profile," are given in an appendix. However, the sites are not classified by the system presented in the previous report, nor is any mention made of this system. Photographs, as well as detailed data on soils trafficability and vegetation analyses, are given in appendices. The following conclusions are presented: (a) Environment of the study area is a resultant of the geology and climate, and of the vegetation produced by geology and climate. (b) The sites are made up of the following elements: tidal flats, topographic highs (barlike features) separating tidal flats from marshes; marshes with tidal channels and hammocks (topographic highs with dense vegetative cover). (c) Soils are predominantly poorly graded sands with admixtures of peat in the marshes, which latter become critical trafficability obstacles. Limestone outcrops occur in the tidal flats and hammocks. (d) The sea-land boundary zone can be relatively easily penetrated by personnel familiar with the terrain. (e) The tides on the investigated area are mixed. Tidal ranges are about 1 meter, but higher and lower ranges occur. Velocities and directions of current in the tidal channels are erratic. Tables, maps, illustrations and appendices.

KEYWORDS: Beach terrain; Beach trafficability; Land-water interface; Marshes; Surface geometry; Trafficability; Vegetation; [Florida]

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In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

Meyer, Marvin P

A bibliography with abstracts of U. S. Army Engineer Waterways Experiment Station publications related to vehicle mobility. Vicksburg, Miss., 1976.

430 p. 27 cm. (U. S. Waterways Experiment Station. PSTIAC report 3)

Prepared in Pavements and Soil Trafficability Information Analysis Center.

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